nature and science

Volume 3, Numbers 1-18

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'EACHER'S EDITION

)L. 3 NO. 1 / SEPTEMBER 20, 1965 / SECTION 1 OF TWO SECTIONS

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**' assigning NATURE AND SCIENCE
ticles for reading at home or aloud
class, the teacher not only helps
ung people develop their reading
ility, but instills a love for learning
m the printed word that can be of
elong benefit.**

nature
and science

If you're subscribing to NATURE
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In the following pages, you'll find
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ew stories, reports, photographic es-
ıys, investigations and projects NA-
URE AND SCIENCE has in store
r you and your students during the
ming year.

ience Adventures combine photo-
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ur students to all kinds of major
ientific inquiry. In the course of the
hool year, these articles and reports
ill cover virtually all of science's
logy's": anthropology, archeology,
ology, entomology, geology, herpe-
logy, ichthyology, mammalogy, or-
thology, paleontology!

Each of the articles is written in a
ay that doesn't talk down to young-
ers, yet is always lucid and easy to
ad. By the end of the year, you'll be
rprised how much their vocabularies
ıve expanded! Articles make excel-
nt home reading and good subjects
r special assignment.

ow It Works Articles. NATURE
ND SCIENCE attempts to achieve
balance between theoretical and ap-
ied sciences. One of the magazine's
ost popular features is the page in
most every issue that "takes apart"
usehold and everyday appliances:
e electric light switch, the water faucet, the clock. You may find some parents who are willing to surrender one or more of these objects so the child can bring it to class and share a demonstration with his schoolmates.

NATURE AND SCIENCE Workshop Projects in each issue teach boys and girls how to organize their thoughts and how to communicate them to other people—virtues that are of importance and value no matter what career the child eventually decides on.

INSIDE

suggestions for using the material on these pages

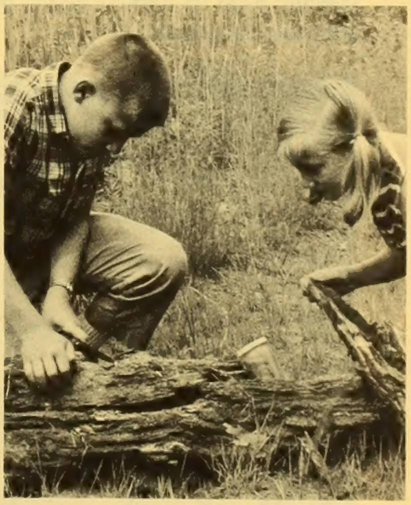
AND NEWS OF OTHER ARTICLES IN PROGRESS

Each issue of NATURE AND SCIENCE takes up at least half a dozen different aspects of science, designed not to replace but to augment the curriculum. From time to time, special issues will cover subjects such as Oceans, Ancient Life, Animal Populations, Weather in depth.

Science Workshops and Investigations. These pages suggest ways young people can start scientific collections, build their own equipment, and make their own firsthand observations. Most projects use everyday materials readily available in the home—milk cartons, window screen, straws, bottle caps, string, blotting paper, aluminum foil. The idea is to teach by example, by doing.

Brain-Boosters. Each issue of NATURE AND SCIENCE contains a page or more of educational puzzles that challenge the imagination and reasoning power of boys and girls and pose small projects that help them fill odd moments constructively. Brain-Boosters have a magnetic attraction for young readers, and often for their parents as well.

Each major feature in NATURE AND SCIENCE will be covered in your own Teacher's Edition—supplying you with practical, tested suggestions for making the most of the magazine's features, and at the same time bringing you news of general interest to science teachers. *The Teacher's Edition accompanies your desk copy of* NATURE AND SCIENCE *– both are free for teachers ordering ten or more subscriptions* ■



The lesson that is best remembered is the one learned by direct experience. NATURE AND SCIENCE encourages youngsters to use their spare time performing simple but enlightening investigations and experiments: making a water clock or astrolabe; measuring the heat absorption of colors; testing the effect of gravity on plants.

USING THIS ISSUE OF NATURE AND SCIENCE IN YOUR CLASSROOM

PAGE 4 Raccoons

In this article on raccoon behavior, the author presents evidence that wipes out the myth that "raccoons always wash their food." In the first place, raccoons often feed in places where there is no nearby water. Most mammalogists now conclude that the raccoon is a "feeler," or "investigator," but not a washer.

Topics for Class Discussion

- *Why is the raccoon such a common animal in the United States?* Raccoons are highly adaptable, a characteristic of most widespread species, including humans. They can live in a wide variety of habitats, from wilderness to suburbia, and from mountain to bayou. They are usually classed as *omnivores,* eating both plant and animal matter. Compare the abundance of raccoons with those of less adaptable animals, such as the whooping crane, bald eagle, or bison. These animals, now much reduced in numbers or threatened with extinction, have much more specific food or habitat needs than the adaptive raccoons.
- *How are raccoons useful?* Raccoon fur has waned in popularity, but many thousands of raccoons are still trapped for their fur. (Some children may be aware of the Davy Crockett 'coonskin hat craze of a few years ago.) The meat is edible and considered a delicacy by some. In the wild, raccoons are part of many food chains, consuming plants and animals, and being consumed by a few larger predators. Man, however, is now their chief enemy.

CERTAIN articles in *Nature and Science* offer teaching possibilities far beyond those suggested in the articles themselves. In this space, in each issue of the Teacher's Edition, we present additional background information about the subject matter and the scientific concepts involved in such articles, as well as suggestions for using them in your classroom.

These suggestions, including topics for class discussion and often additional activities that can be carried out by your pupils, are offered to help you guide your pupils to deeper understanding of the scientific concepts involved, and to awaken them to some of the broader implications of those concepts.

—The Editors

PAGE 7 Soil Hardness

Even if your school is surrounded by macadam and concrete, this simple workshop can be done at a nearby park. Here are some additional investigations your pupils may want to try:

- Make a simple map of the soil compaction zones in a school yard, back yard, or park. Then see how the map compares with another map of the plants growing in the same areas.
- Find out if the dryness of soil affects the speed with which water soaks into it. You can do this by repeating the first investigation described on page 7 of the student's edition, using two juice cans instead of one. Force two cans partway into the soil, side by side. Then put some water in one can and let it soak into the soil. Finally, pour equal amounts of water into both cans. Does the water soak in at the same rate in each can?

This investigation leads to an important rule in designing experiments: Test one thing at a time. If the "soaking speed" of soil is being used as an indicator of soil compaction, it is important that all the testing sites be equally dry. Otherwise, two things are tested—soil compaction *and* moisture.

PAGE 11 The Fly—Part 1

Houseflies provide one answer to the perennial question: "What sort of project can my pupils do that will involve them individually in studies of living material?" Here is a unit that poses few problems of space, equipment, and time. All the materials needed are ordinary household items; the cages and breeding jars take little space; and the project can be carried out by pupils working singly or in small groups.

The procedures described in this two-part Science Workshop on the housefly have been used successfully in several fifth and sixth grade classrooms. Dr. Nancy Kent Ziebur, author of the article and these suggestions for using it in your classroom, is a geneticist in Binghamton, N.Y. She became interested in the subject through experience with her own children, with Girl Scouts, and as a substitute teacher in science classes.

The minimum project (observing the stages of the fly's life cycle) should take only a couple of hours of classroom time. The cycle from eggs to adult takes at least three weeks, but after eggs have been laid in the breeding jars, development can be observed during spare moments in the school day.

Housefly raising is simple, yet it has the virtue of challenging the pupils at different levels. Some of the boys will doubtless excel in fly catching. Other pupils will be fascinated by the behavior of the maggots and the adult flies. The practical, health aspects of fly life will interest some children. A few may be drawn into a study of questions which investigations like those suggested on page 14 can help to illuminate. All will be genuinely excited when the first flies hatch out of the pupal cases.

Part 1 of this article tells how to identify, cage, and feed the housefly, and suggests some ways to study it. Part 2, in the next issue, tells how to rear houseflies and observe their life cycle, and suggests investigations of the behavior of larvae under various environmental conditions.

(Continued on page 7T)

NATURE AND SCIENCE is published for The American Museum of Natural History by The Natural History Press, a division of Doubleday & Company, Inc., fortnightly, October through April; monthly, September, May, June and July (June and July special issues). Second Class postage paid at Garden City, N.Y., and at additional office. Copyright © 1965 The American Museum of Natural History. All Rights Reserved. Printed in U.S.A. Editorial Office: The American Museum of Natural History, Central Park West at 79th St., New York, N.Y. 10024.

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Previews of the next seven issues

VARIETY IS THE SPICE...

After our first 36 issues, and two years of valuable comments on *Nature and Science* from hundreds of children and teachers, the editors are convinced that one of our greatest contributions is the variety that we provide.

We believe in variety in the *ways* we offer things. Notice how we mix articles that get children thinking by reading with ones that get children thinking by doing. We mix articles that *tell* with articles that *ask*.

We also believe in variety in the *kinds* of things we write about. Notice in the seven columns that follow, highlighting issues 2-8 of *Nature and Science,* that we do not offer a rehash of traditional textbook topics. Instead we use such topics merely as a starting point carrying the child into the new world of thought and discovery and new ways of looking at the familiar in their immediate surroundings.

Rather than treating fossils as gee-whiz curios, they become windows to past ages of the earth (See Issue #3). Analyzing a glass of milk becomes an adventure in the ideas and methods of modern chemistry (See Issue #5). A report on what is new on the scientific study of dogs becomes a child's new dimension in the enjoyment of his pet (Issue #5).

We will take your pupils into the world of Indian life before the arrival of European settlers (Issue #2); to an underwater colony that your pupils themselves may visit before their 21st birthday (Issue #7); to the interior of a molecule that has been frozen to 270 degrees below zero (Issue #5); to the remote breeding grounds of giant Caribbean sea turtles (Issues #4); to the rocky shores of a brand new two-year-old island where signs of life are already beginning to flourish (Issue #6).

This is just a sampling of the first semester of this year's *Nature and Science,* but we hope you will keep it as a guide to how you can plan ahead in using *Nature and Science* in your classes.

Issue 2 *October 4, 1965*

THE TWO WORLDS OF ISHI

The last truly wild Indian in the U.S. gave himself up in a small California town in 1911. For five years Ishi was the subject of great interest from anthropologists. Recently told in book form, here for *Nature and Science* readers is a story of how those who got to know Ishi deepened their sense of what it means to be a human being.

THE FLY—Part 2

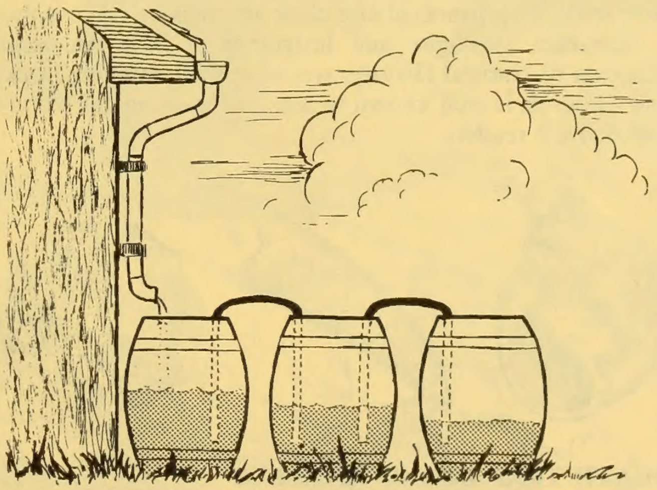
Here is a follow-up on the SCIENCE WORKSHOP that began in Vol. 3, No. 1 with instructions for building a fly cage, catching houseflies, and starting a colony of them. Part 2 gives your pupils complete instructions for carrying out seven open-ended investigations into the eating habits, chemical sensitivity, predator-prey relationships, and temperature sensitivity of houseflies at various stages of their life cycle.

TAKE THE COLOR FROM LEAVES

Why do leaves change color? There are plenty of good descriptions for children that explain the chemistry of summer's green turning to rich gold and red, then fading to dull, dead brown. But even better than reading is letting the children see for themselves. This WORKSHOP introduces children to paper chromatography—a widely used scientific technique applied here to separate the pigments that color leaves. Equipment: peanut butter jars, blotting paper, and a drop or two of rubbing alcohol.

SLIPPERY WAYS OF SIPHONS

Always a source of amazement, the siphon's workings are first neatly explained, and then the pupil is given a set of siphon "situations" and asked if each would actually work.



WHEN IS A PLANT NOT A PLANT?

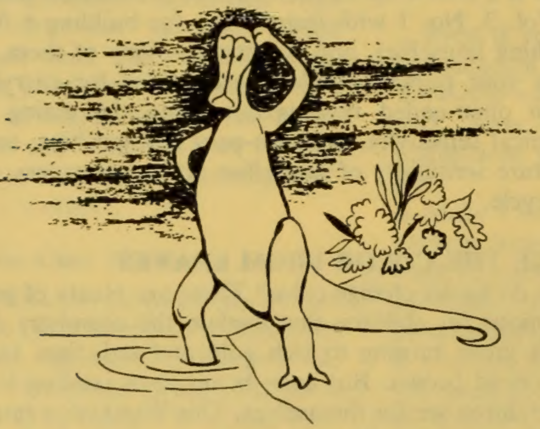
An engaging article by *Nature and Science* Senior Editor Laurence Pringle on telling the differences between plants and animals. Sometimes this isn't as easy as it might seem, particularly when considering sponges, euglena, or other simple forms of life in a pond.

Issue 3 *October 18, 1965*

EXPLORING PREHISTORIC LIFE (SPECIAL ISSUE)

THE DUCK-BILLED DINOSAUR CAPER

Chances are that the dinosaur books in your classroom or library show duck-billed dinosaurs as swamp dwellers that fed on soft, water plants. This new look at the fossil evidence, by the paleontologist Dr. John Ostrom of Yale's Peabody Museum, reveals quite a different life for these ancient North American reptiles.



POLLEN CLOCKS

A botanist tells how tiny, microscopic pollen grains are dug from ponds and bogs, then studied to reveal the vegetation, climate, and animal life of past ages.

START YOUR OWN FOSSIL COLLECTION

These instructions, useful in any part of the country, show your pupils where to look for fossils, how to free specimens from surrounding rock, how to label, mount, and catalog their finds. This practical and clear article is by Christopher J. Schubert, geologist and instructor at The American Museum of Natural History, whose special issue on Rocks and Minerals is well known to tens of thousands of *Nature and Science* readers.

DEATH TRAP OF LOS ANGELES

Not a freeway, not smog, but the famous LaBrea tar pits, where the remains of giant sloths, dire wolves, and saber-toothed cats make up one of the most spectacular fossil finds in the world. Here is how scientists reconstruct life in Los Angeles as it was 15,000 years ago by working from the fossils in the tar pits, and how they figure out why many of these unusual animals have become extinct.

Issue 4 *November 1, 1965*

MIXING COLORS OF THE RAINBOW

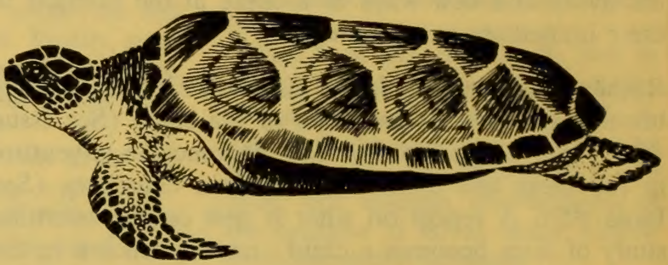
A workshop in which a make-it-yourself water prism, a few bits of colored cellophane, and a flashlight are put to use to explain color and color perception in a memorable way for any child. This article with its many fresh investigations is by *Nature and Science* contributor, Diane Sherman.

COAT HANGER THERMOMETER

With a coat hanger, a few small pieces of wood, and 16 inches of copper wire, your pupils can make a thermometer of considerable accuracy. This is the first of a series of three articles on heat and cold by *Nature and Science* Contributing Editor Roy A. Gallant, which will provide excellent enrichment in the physical sciences, introducing your pupils to concepts of molecular activity in solids, liquids, and gases.

THE VOYAGES OF THE GREEN TURTLES

In an article especially written for *Nature and Science*, Archie Carr, the well-known biologist, tells how he and his colleagues have recently tracked the lumbering green turtles in their incredible migrations from their Caribbean nesting isle to feeding grounds hundreds, even thousands, of miles away. But the scientists are still baffled: Do the turtles navigate by scent? By following landmarks? Do they surface and navigate by the stars or the sun?

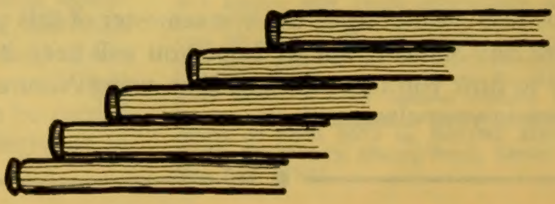


TURTLE DETECTIVE

Here is a capsule biography of the exciting life and explorations of Professor Archie Carr of the University of Florida whose quest into the habits of sea turtles has led him into fruitful adventures while probing the tropics of the world.

WHAT HOLDS IT UP?

How a stack of books can be made into a "crazy cantilever" and illuminate the idea of center of gravity in theory as well as in architectural practice.



nature and science

VOL. 3 NO. 1 / SEPTEMBER 20, 1965

RAISE HOUSEFLIES?

Why not! Here is how you can start a colony of flies and investigate their lives.

see page 11

New Views of

THE RACCOON'S WORLD

see page 4

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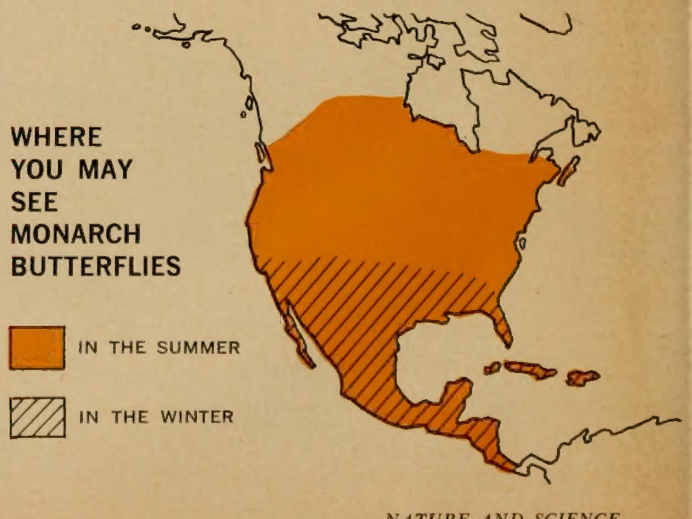
Hundreds or thousands of monarch butterflies sometimes roost together as they fly southward in the fall. You can help scientists find out where they travel and how far they go.

■ Some evening in the early fall, you may see a tree covered with orange-colored butterflies. Blink your eyes, rub them, and look again. Yes, they're still there—hundreds, perhaps thousands, of monarch butterflies *(see photo)*. You may wonder: What are they doing there? Where did they come from? Where are they going? Scientists wonder too.

Monarch butterflies live in many parts of the United States and Canada. You can recognize monarchs by their large size and bright color. They usually measure about four inches from wingtip to wingtip. Their wings are orange-red, surrounded by a wide margin of black dotted with pure white spots. The veins that form the framework of their wings are black. You have probably seen them in the summer—floating through your yard, or across the road ahead of a car. The monarch is a very strong flier.

The monarchs you see clustered on a tree started life earlier this summer from small eggs. Each egg is about half the size of a pin-head, and is attached to the underside of a milkweed leaf. In about five days a tiny caterpillar emerges from the egg. Its first meal is its own eggshell! After that it feeds only on milkweed leaves until fully grown (about two inches long). During this time it has shed its skin four times. The caterpillar's skin does not grow and has to be shed. Underneath is a new and larger skin.

When it sheds its skin a fifth time, the result is a beautiful *pupa* (sometimes called the *chrysalis*). The caterpillar hangs itself from some object, the skin splits along the back, and



Ref

Treeful of Butterflies

but comes a pupa. The pupa hardens into a jade green ewel decorated with jet black and gold spots.

From the time the caterpillar hatches from the egg until t changes to a pupa may be up to 15 days. Or the time may be shorter, depending on the temperature and perhaps also on other, unknown factors. Within the pupa the change to a butterfly is completed. After about eight days a monarch butterfly emerges from the pupal case.

South for the Winter

During the summer this life cycle is repeated several imes, but in the fall no more eggs are laid, and the butterflies begin to *migrate,* flying southward for the winter. At his time you may see several monarchs, or a swarm of thousands that seem to be flying together. They are not flying as a group, though, like a flock of ducks. Each monarch is making its own way southward. The reason that you may see so many of these butterflies together at one time is that from ime to time they gather by the thousands, and tens of thousands, resting on trees and shrubs for several days. Then they move on. Once a man told me that he had driven a car for wo hours through a mass of migrating butterflies in Kansas.

Eventually they reach their wintering grounds along the Gulf Coast, in Mexico, and in the southwestern states *(see map).* Pacific Grove, California, has set aside as a city park an area where the monarchs winter.

When spring comes the butterflies start their northward ourney. But how far they fly is still a mystery. We know hat they stop along the way to lay eggs. But no one knows yet whether they fly all the way back to their starting point. Whatever they do, within two or three months after hey leave their wintering ground, there are monarchs again n their northernmost summering areas, as far north as Canada. The offspring of the females that fly northward n the spring are the butterflies that migrate south early in he following autumn.

Watch for Monarchs with Tags

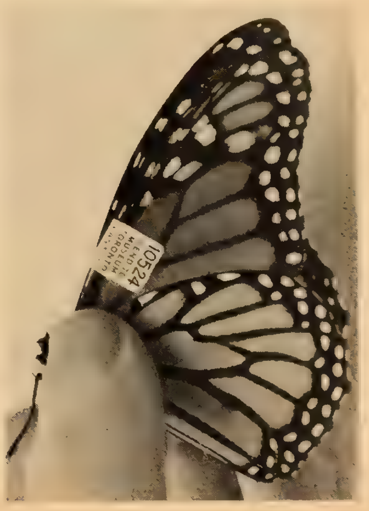
For a long time it was thought that the butterflies were born with an instinct that guided them in the right direction on these migration flights. Today, scientists think that the butterflies are kept moving southward or northward by

the weather and climate conditions along the way, but very little is known about this.

Many people are trying to find the answers to some of these questions by marking the butterflies. The identity "bands" that are used are little tags of waterproof paper. Each tag has a different number and the address to which the tag should be sent if you find it. The tag is glued to the front edge of the leading wing of a butterfly *(see photo).*

Very few banded monarchs are found again, because very few people look for bands on butterflies. You might be lucky enough to find one. With enough people helping, maybe another piece can be fitted into the jig-saw puzzle of the life of the monarch butterfly.—Harvey L. Gunderson

If you find a butterfly like this, send the tag with the date and place you found it to the address on the tag. In this way you can help scientists find out more about where monarchs travel on their spring and fall migrations.



my friends, THE RACCOONS

by
Leonard Lee Rue III

For thousands of hours, I've watched, studied, photographed, hunted, and read about raccoons. Some of the things I've discovered about these appealing animals may surprise you.

"I cannot remember a time since I was in my early teens when I did not have one or more raccoons as pets," says the author, Leonard Lee Rue III. Thousands of Mr. Rue's photos of wild animals have appeared in magazines and books. He lives in Columbia, New Jersey, with his wife and three sons. In the summer he leads canoe trips for teen-age boys in the Canadian wilds.

■ What does the average person know about raccoons? That they have a black mask across their eyes, a ringed tail, and that they always wash their food before eating. That's not too bad for a starter; it's what everyone has always heard and read—even if it is not the truth. Oh, it's true enough that raccoons do have masks and ringed tails. But it is time that we set the record straight about the washing of their food.

Raccoons catch or find most of their food along the water's edge. Across most of the United States, the shorelines of brooks, rivers, ponds, and marshes are usually covered with their tracks. There the raccoons feed upon crayfish, mussels, clams, frogs, minnows, muskrats, and anything else that is edible.

Raccoons have a tremendous appetite and a boundless curiosity. Everything that they find, edible or not, is usually picked up and handled. Humans have a fair sense of touch, but that of the raccoon is much more sensitive. Raccoons have a greater concentration of nerve endings in their fingers than humans have. (They can feel things better when their fingers are wet, and so can you. Try running your fingers over an object that is dry, then put it in a sink and try it underwater.)

When a raccoon is hunting in shallow water for crayfish or minnows, it doesn't even look at what it is doing. It will glance all about, not seeming to care what its forepaws are doing. Sometimes a raccoon will sit down in the middle of a pool of water and allow minnows to hide in its fur.

Then it easily catches them with its nimble fingers. After a raccoon catches some food, it turns the morsel over and over in its fingers before eating. It seems to be washing its food. But is it?

Plop, Pound, and Pull

I have kept raccoons as pets for many years. In studying and caring for them, I have paid particular attention to "food washing." Usually, when I gave the raccoons a piece of meat, they would carry the food to their water pan, plop in the meat, pound it, pull at it, and then eat it. This certainly looked as if the animals were washing the meat. The next time, before feeding them, I took the water pan out of the cage. Again the raccoons went through the same motions. They handled the meat, pounded it, pulled it, and then ate it, all without the benefit of water.

Recently I had the opportunity to take photographs of a big raccoon feeding on a dead shad. The shad had washed up on the river bank where it laid out in the sun. It was starting to decay. Although water was only about four or five feet away, the raccoon did not try to wash the fish but just started eating it. It liked the flavor of the fish just as it was. When a motor boat scared the raccoon, it grabbed the fish and took it into the high grass.

Some people claim that raccoons have to wash their food because they have no glands in their mouths to give off saliva. According to this idea, raccoons must wash their food to make it wet enough to swallow. However, Dr. Leon F. Whitney, a veterinarian from Connecticut who is an authority on raccoons, has examined the mouths of many dead raccoons, looking for saliva glands. He found that raccoons have ample glands, and produce enough saliva for their needs.

I'll never forget the look of surprise on the face of one of my raccoons the first time he put dry saltine crackers in water. The crackers soaked up water and fell apart. He frantically tried to fish out the pieces before they sank. He never put another cracker in water.

How "Smart" Is a Raccoon?

Raccoons have often been tested by scientists who study learning in animals. Most of these tests have to do with getting food. The scientists found that raccoons can learn to pull on a string to lift a basket with food inside. In another test, a raccoon chained by its neck was unable to reach some food with its front feet. It turned around and, backing up, grasped the food with its hind feet. Raccoons have no trouble pulling out corks, unfastening bottle tops, opening door latches or turning knobs. They can solve many, but not all, of the tests designed to test the intelligence of monkeys.

(Continued on the next page)

Raccoons roam far and wide, investigating many places for food. Sometimes their curiosity leads them into trouble. This raccoon took an unexpected swim.

When a raccoon explores the bottom of a stream or pond for food, it doesn't need to look at what it is doing until it catches something in its sensitive fingers.

Raccoons live in parts of all the United States, except Hawaii and Alaska. (Raccoons have been let go on some islands near southern Alaska.) They usually weigh about 12 to 16 pounds, although one captured in Wisconsin weighed 62 pounds.

In New Jersey, where I live, we find a wide range in raccoon color. Some look yellow, some gray, and some almost black. The color of a raccoon's coat depends on the color of its long, kinky *guard hairs*. These hairs cover the soft, dense underfur.

Raccoons sometimes upset garbage cans in their search for food. They eat many kinds of food. This is one of the reasons for their abundance in the United States.

Early European settlers of North America found many uses for raccoon fur. The skins were made into robes, hats, and other garments. They also served as a form of money. In 1788, one southern state paid the governor's secretary a salary of 500 raccoon skins.

Finding Wild Raccoons

Most people see raccoons during the summer, when city dwellers go to summer cottages, country homes, and campsites. There they may be awakened—and sometimes frightened—by the loud banging and clanging of garbage cans as the lids are knocked off by marauding raccoons. If a raccoon finds a certain garbage can to be a ready source of food, it will return to it night after night.

Many people enjoy these visits and deliberately leave food for the animals. In fact, the raccoon is probably the easiest mammal to attract with food offerings. My neighbors, Geri and Mike Mordkin, have been feeding raccoons for several years. They began one night when a raccoon raided their garbage pail. Geri promptly put food scraps on the porch. First she left the porch light on; finally she left the door open.

With more time and food, the raccoon finally got to the point where it would come into the house and pick up the food, although it preferred to eat outdoors. Many people came to see the Mordkins' unusual dinner guest. The raccoon even got used to the popping of flashbulbs, as everyone wanted photographic proof of the raccoon's visit.

The next year the raccoon came back with her family. The three young ones never became as bold as their mother, but they all crowded around the open door while the mother went into the living room and picked up pieces of apple to take to them.

At the Boy Scout camp where I used to live, the boys often bring fruit, cookies, and candy from home. These goodies are stored in the tents and shelters where the boys sleep. Almost every night the camp is raided by both skunks and raccoons. Some of the animals travel a regular route from one tent to another. Of course the boys don't mind. They welcome the chance to see these wild animals at close range.

Raccoons as Pets

Young raccoons make fascinating pets, but they should not be kept beyond two years of age. Beyond that age they may be dangerous—I have the scars to prove it.

It is not wise to let young raccoons free in a house. They seem to think that drapes and curtains are put there to test their climbing ability. They explore wherever there is food or water—on kitchen tables, counters, sinks, bathtubs, toilets. Raccoons in a house usually tear more apart in 10 minutes than anyone can straighten up in an hour.

Sterling North, in his book *Rascal,* tells of his delightful experiences with a pet raccoon. His experiences are similar to those of anyone who raises these animals. In the end Mr. North had to release his pet, and so does almost everyone else. Many states now have laws forbidding most kinds of wild animal pets. These animals are better off, and more useful, living their normal lives in the wild ■

■ For more information about raccoons, look in your library or bookstore for these books: **The World of the Raccoon,** by Leonard L. Rue III, J. B. Lippincott Company, New York, 1964, $4.95; **Rascal,** by Sterling North, Avon Books, New York, 1964, 60¢ (paper).

HOW HARD IS THE SOIL?

BY CLIFFORD E. KNAPP

■ Tramp, tramp, tramp. You are walking along a path, or across a lawn or field. Every step you take may affect the soil and plants growing in it — perhaps for years to come.

How can your footsteps be so important? To find out, fill two jars or plastic containers with soil. In one of the jars, press the soil down firmly with your fingers or a blunt-ended stick. Then pour equal amounts of water—about two ounces—in each jar. How long does it take for the water to reach the bottom of each jar?

When you pressed the soil down in one jar, you squeezed the particles of soil together. You closed most of the tiny air spaces that were there before. When soil is pressed firmly, it is called *compacted* soil. Water soaks very slowly into compacted soil and this affects the plants that grow in the soil.

In one experiment, scientists found that pine trees growing in compacted soil grew only half as much as trees of the same kind growing in normal soil. Compacted soil is slowly loosened by the roots of plants and by animals such as earthworms. But the scientists estimated that it would take about 40 years for the compacted soil to become loose enough for the pine trees to grow at their usual rate.

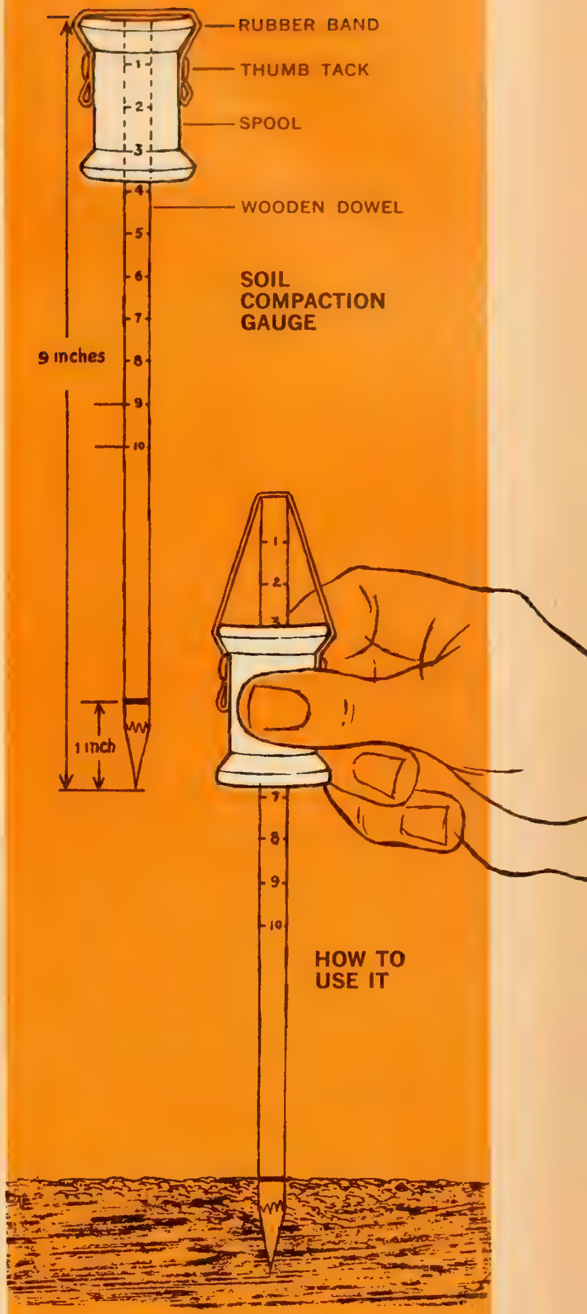
Testing Soil Hardness

You can make a simple instrument to measure soil compaction in your neighborhood. You will need two thumb tacks, a wide rubber band (#84 rubber bands are about one-half inch wide), an empty thread spool, and a nine-inch length of dowel (you can buy dowel at a hardware store). The dowel must slide easily inside the spool.

First, sharpen one end of the dowel in a pencil sharpener. With a ruler, measure one inch from the point and mark a dark line with a pencil. Then measure from the unsharpened end of the dowel and mark off ten lines, each a half inch apart. Number these ten lines, starting with number 1 near the unsharpened end. Fasten the wide rubber band to the top of the spool with a tack on each side (*see diagram*). Your soil compaction gauge is now ready to use.

Slip the dowel into the spool and pull down on the spool, forcing the point of the dowel into the soil up to the dark-line (*see diagram*). When the pointed end is in this far, read the number at the top edge of the spool. This number will tell you the soil compaction for that location.

Try other places—make tests on a lawn, on a path, under a tree, on the slope of a hill, in a garden. Where is the soil most compacted? Where is it least compacted? Are the plants in each place of the same kind? If you find the same kind of plants growing in areas with different soil compaction, is there any difference in their size, number, or condition? ■



INVESTIGATIONS

- Take a large juice can (No. 5) and remove both ends with a can opener. Force one end of the can part way into the soil and pour a quart of water into it. With a ruler, measure the depth of the water every minute for a short period of time. How fast does the water soak into the soil? How does this compare with the soil compaction number?
- What happens to a small plant when you compact the soil around it in a circle of one foot diameter? How long does it take to find the answer?

what to WEAR on the MOON

■ By 1970 or sooner the United States may land men on the moon in the space program called "Project Apollo."

When the Apollo space ship gets near the moon, two astronauts will put on their suits and ride to the moon's surface in a small landing craft. Then the astronauts will step out of the craft—into a world where temperatures soar to 250°F by day and plunge to 250° below zero by night; where there is no oxygen to breathe; where meteoroids strike the surface like bullets; and where blinding sunlight is reflected from the moon's surface.

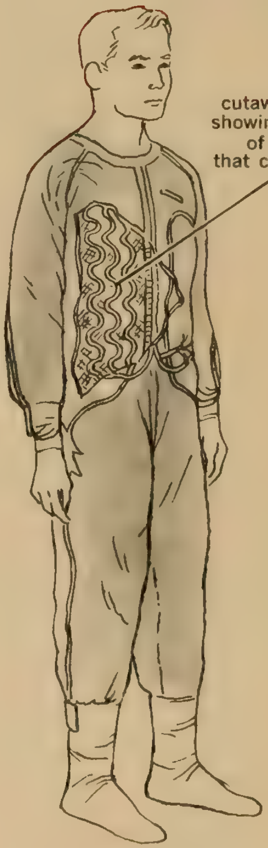
Space engineers have tried to design a space suit that will protect an astronaut from the hostile world of the moon, yet allow him to move about freely. The diagrams and captions on these pages show the Apollo suit that is now being tested by the National Aeronautics and Space Administration ■

HELMET This li
helmet is now be
It has a wider vi
dow than earlie
Inside is radio
that allows the
to talk with one a
with the moon lan

ZIPPER The pressure suit has a double zipper—one inside and one outside—to keep oxygen from escaping from the suit.

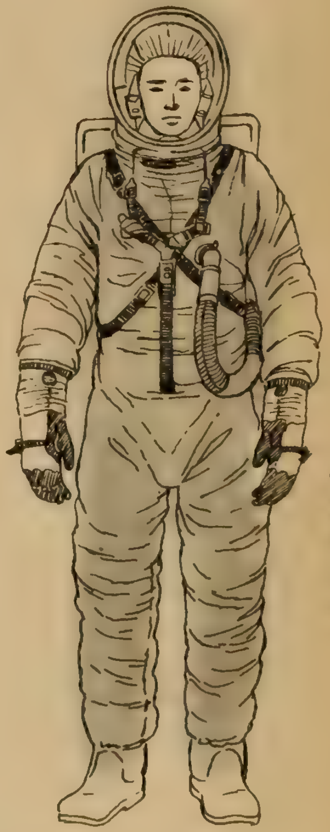
METAL FITTINGS The fittings at neck and wrists hold the helmet and gloves tightly to the pressure suit so there's no loss of oxygen.

RUBBER JOIN
these joints,
inside the suit
it too stiff for
to bend his a
easily.


cutaway view, showing network of tubes that carry water

UNDERGARMENT

The inner part of the space suit is water-cooled. Water is pumped from the back pack into the undergarment. It flows through a network of small tubes over the body surface, soaking up body heat. Then the warm water is returned to the back pack where it is cooled and ready to use again. The astronaut can set the temperature of the water that cools him—at 45°, 65°, or 77°F.



GLOVES T
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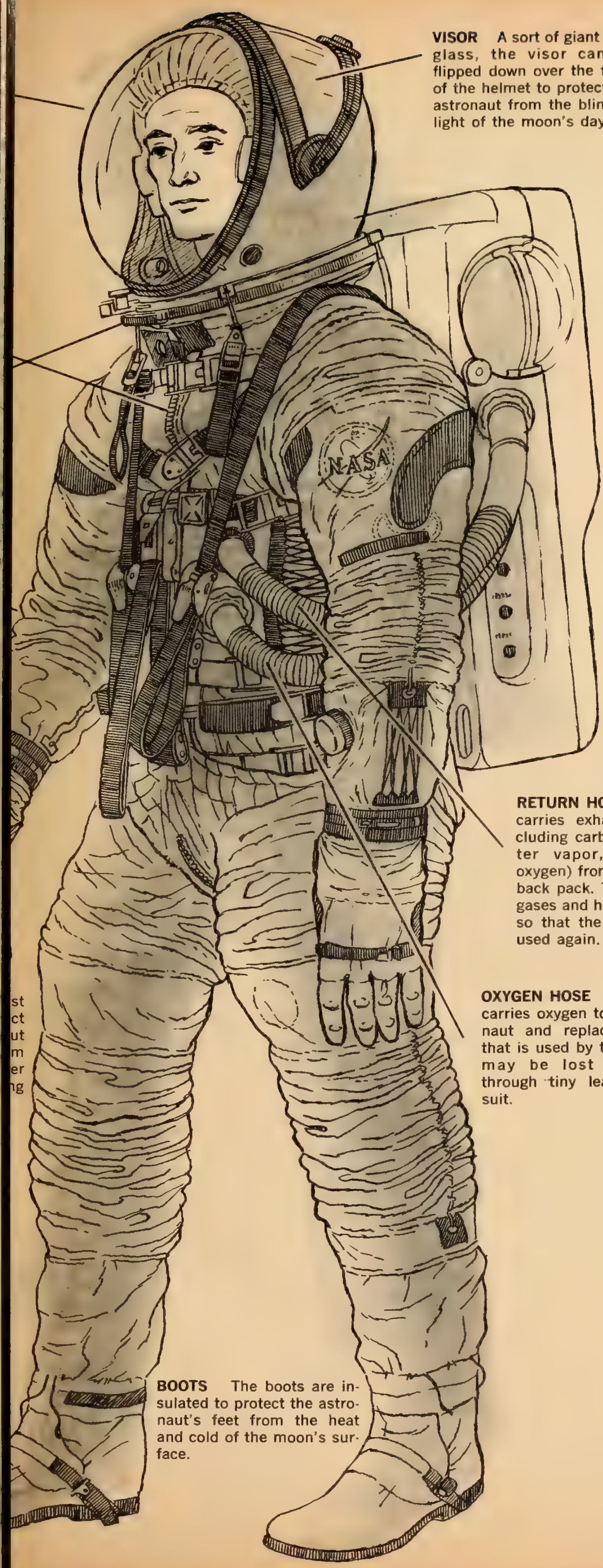
instruments
the moon.

OUTER GARMENT

The outer part of the Apollo suit is made of many layers of cloth that insulate the astronaut from the intense heat and cold of the moon. This part of the suit also protects the astronaut from meteorites; it's about as strong as a thin sheet of aluminum. An astronaut should be able to don the three main garments of the space suit, plus helmet and back pack, in five minutes. A little later, he will step out onto the moon.



VISOR A sort of giant sunglass, the visor can be flipped down over the front of the helmet to protect the astronaut from the blinding light of the moon's day.

RETURN HOSE This hose carries exhaled gases (including carbon dioxide, water vapor, and unused oxygen) from the suit to the back pack. There the waste gases and heat are removed so that the oxygen can be used again.

OXYGEN HOSE This hose carries oxygen to the astronaut and replaces oxygen that is used by the body or may be lost to space through tiny leaks in the suit.

BOOTS The boots are insulated to protect the astronaut's feet from the heat and cold of the moon's surface.

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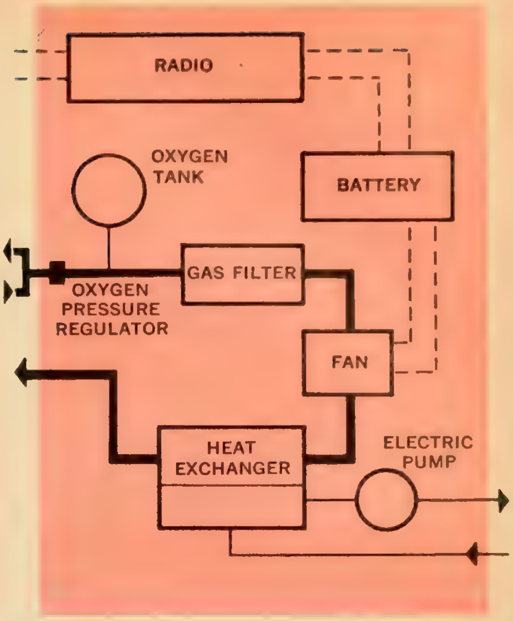
BACK PACK



The back pack gives the astronaut the oxygen and air pressure he needs for life. Without it, he would die in an instant. This diagram shows what is inside the back pack and how it works.

BATTERY The battery (made of nickel and silver) powers the fan and the radio equipment.

OXYGEN TANK This tank contains a four-hour supply of oxygen for the astronaut to breathe, as well as oxygen that keeps a constant pressure on the astronaut's body.

FAN The fan pushes oxygen into the suit and also forces exhaled gases from the suit to the back pack.

OXYGEN PRESSURE REGULATOR This device controls the flow of oxygen to the pressure suit. It keeps the suit at a constant pressure of about 3½ pounds per square inch.

RADIO The radio enables the astronaut to send and receive messages. Another radio device automatically checks the amounts of oxygen and air pressure in the suit and sends this information to the moon landing craft.

GAS FILTER Exhaled gases from the suit are returned to the back pack and pass through this filter. Carbon dioxide is removed from the air by a chemical called lithium hydroxide. Other waste gases are removed by a charcoal filter.

HEAT EXCHANGER The heat exchanger cools gases from the pressure suit and also water from the cooling undergarment.

ELECTRIC PUMP This pump forces cool water from the heat exchanger into the undergarment, through a series of tubes in the garment, then back to the heat exchanger.

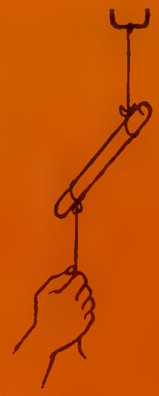
PRESSURE SUIT

The middle part of the Apollo suit is a two-layer pressure suit, designed to keep the astronaut from blowing up like a balloon on the airless moon. Oxygen from the back pack is pushed into the suit through a hose, keeping a constant pressure on the astronaut's body. The oxygen pressure in the suit will be about one quarter of that on earth: enough to keep the astronaut comfortable. The air-tight pressure suit is covered with a layer of material that keeps it from bulging. It also allows the astronaut to move his arms and legs freely.

brain boosters

prepared by **DAVID WEBSTER**

CAN YOU DO IT?

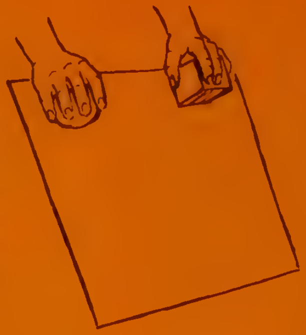


Hang a piece of wood on a thin string with another string hanging from the wood (*see diagram*), and pull down on the lower string. Can you make the bottom string break instead of the top string?

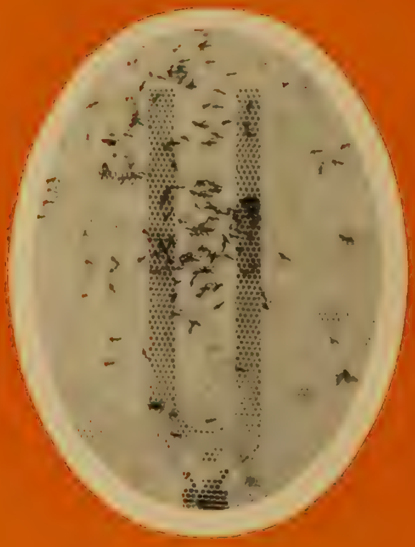
FUN WITH NUMBERS AND SHAPES

How thick is a newspaper page? Can you make some measurements to find out?

FOR SCIENCE EXPERTS ONLY



The picture shows a metal cube and a metal ball held at the top of a smooth wooden ramp. Suppose the cube and ball were released at the same time. Which would reach the bottom of the ramp first?



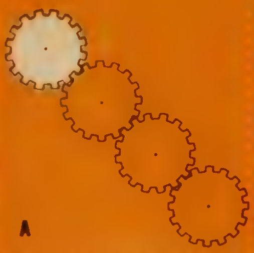
MYSTERY PHOTO

The photograph shows a lot of mosquitos inside a cage. What is making them cluster around the fork-shaped object?

Solutions to these Brain-Boosters will appear with the Brain-Boosters published in the next issue.

WHAT WOULD HAPPEN IF . . .

. . . gears were arranged in sets as shown below? Would you be able to turn the white gear in each set? Which white gears would not move?



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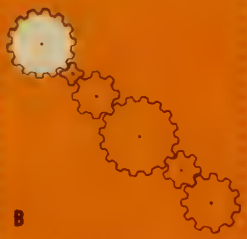

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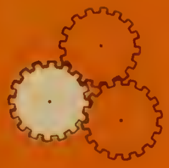

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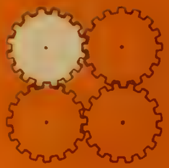

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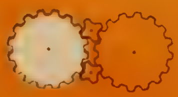

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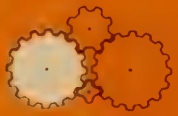

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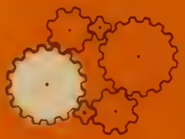

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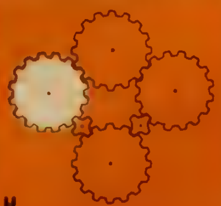

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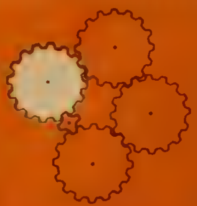


I

THE FLY

PART 1

BY NANCY KENT ZIEBUR

This annoying household pest is a wonderful laboratory animal.

Part 1 of this two-part SCIENCE WORKSHOP tells you how to make a cage for flies and how to catch and feed them. Suggestions are given for five investigations using flies. Part 2 will tell you how to raise flies and how to learn many more things about them by making seven other investigations.

■ (SWAT!) They walk around on your food, leaving germs which they carry on their feet. (SWAT!!) They walk on your walls and windows, leaving spots and specks wherever they go. (SWAT!!!) Nobody loves them. Why, then, would you want to know anything about houseflies? One reason, to control them better. Also, what we learn about flies will help us understand how other insects, and even other kinds of animals, live and behave.

Houseflies are easy to raise. In a small box and a small jar you can watch the life cycle of a fly. As you do, many interesting questions about them will pop into mind. Perhaps you can plan experiments to help find answers.

A cage for adult flies must be designed so that the flies will have food, water, and air. There must be some way to get the flies into the cage, and a way to get them out. If flies are to reproduce, they must also have a suitable place for laying eggs. The cage must not let the flies escape or

(Continued on the next page)

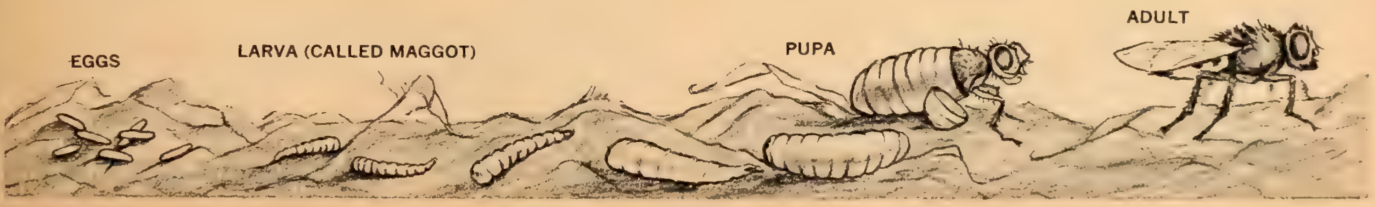
LIFE CYCLE OF THE HOUSEFLY

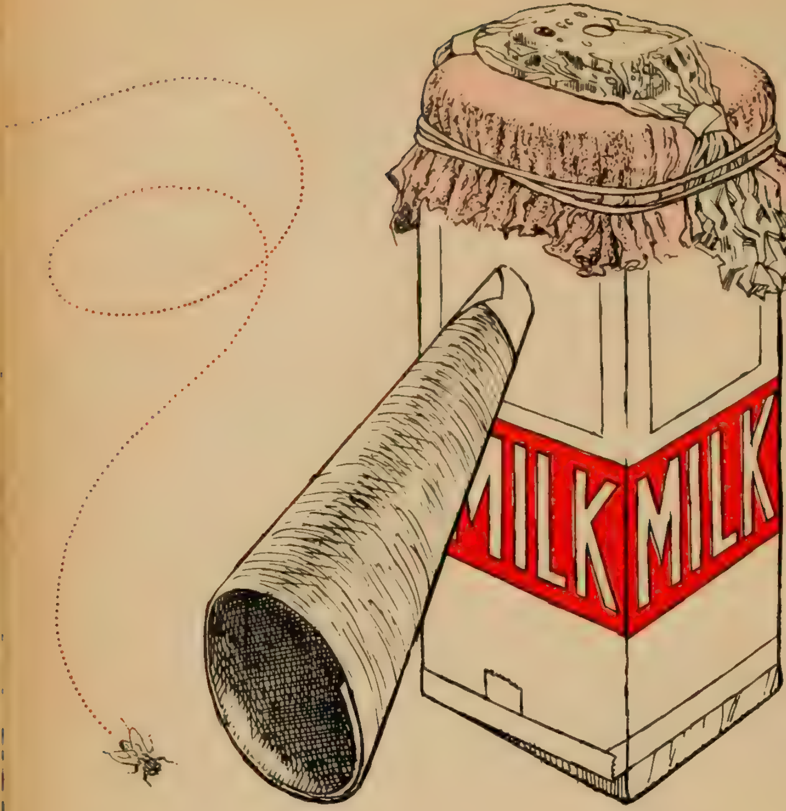
The housefly (*Musca domestica* is its scientific name) goes through four stages in its lifetime: 1) egg; 2) larva (also called maggot); 3) pupa; and 4) adult.

The first stages of development take place inside the egg. When the egg hatches, a *larva* crawls out. The wormlike fly larva does not have legs or wings. As it grows, it sheds its outer layer of skin twice. This is called *molting*. All insects molt. The large housefly larvae which have molted twice are the maggots which many of us have seen at some time.

When the larva stops growing, its skin becomes shorter and stiff, forming a barrel-shaped pupa case. Inside this case the *pupa* develops wings, legs, eyes, and other features which the larva did not have.

About 10 days to two weeks after the egg is laid, the adult fly pushes its way out of the pupa case. It is now ready to buzz into your kitchen and find its first meal as an adult.





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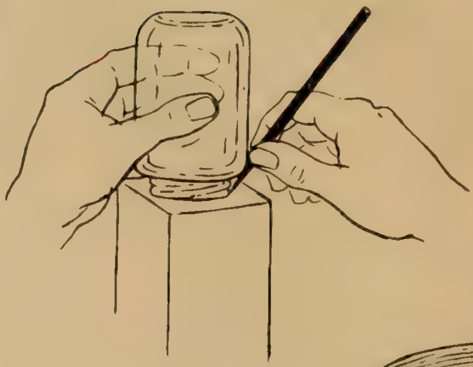
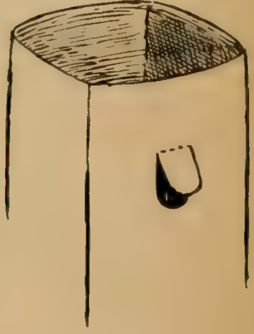


2

Trace a line on the bottom of the carton around the mouth of a small glass jar. Cut a round hole just inside the line you have drawn.



3

Cut off the top of the carton and bend the corners to make the top round. Cut a slit about 2 inches from the top of the carton as shown and bend out the flap.

let other insects get in. You may be surprised to find what small cracks flies can squeeze through.

Before you make the cage shown above in Diagram 1, you should make some food for the flies. In a cup or small dish, mix one teaspoon of powdered milk with one teaspoon of confectioners' sugar. Stir in water, drop by drop, until all of the mixture is moist. Use as little water as you can. Spread the paste on a piece of paper, dividing it into two or three small patches, each about the size of a quarter. Set these food patches aside to dry.

Making the Cage

You will need a clean, dry, milk container (one-quart size is best). Find a glass jar, also clean and dry, whose top is smaller than the bottom of the milk container. You can use a 7¾-ounce baby-food jar or a small jelly jar. Hold the top of the jar against the bottom of the milk carton and trace carefully around it *(see Diagram 2)*. With a sharp cutting tool, carefully cut out the circle you have drawn. (Keep your cut about 1/16 inch inside the line.) The top of your jar should fit *snugly* into the hole. Once you have tested the fit, don't keep moving the jar into and out of the hole, because this will stretch the hole. Put the jar aside now, but save it. You will need it for the flies to lay their eggs in when you receive Part 2 of this article in the next issue of *Nature and Science*.

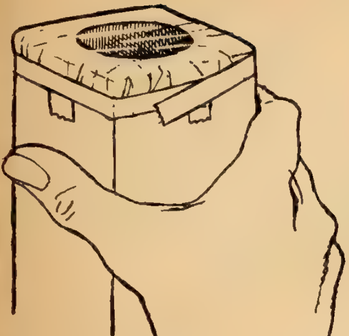
Cut off the top of the milk box and make the edges even, then bend the top of the box until it is round instead of square *(see Diagram 3)*.

Next, make a cone through which flies can enter the cage. Use a stiff paper (such as construction paper, heavy wrapping paper, or the cover of a magazine). Roll a cone about 6 inches long, 2 to 2½ inches wide at the base, and with a hole at the pointed end big enough to slide a pencil into. Fasten the cone together with tape, staples, or both.

Now, the cone must be fastened to the box. To do this, cut a slit like the one that is shown in Diagram 3, about 2 inches from the top of the carton. Bend the flap outward and push the cone into the hole with the point aiming partly up. Fasten the cone to the carton and to the flap with tape. Cover any spaces around the edges with tape.

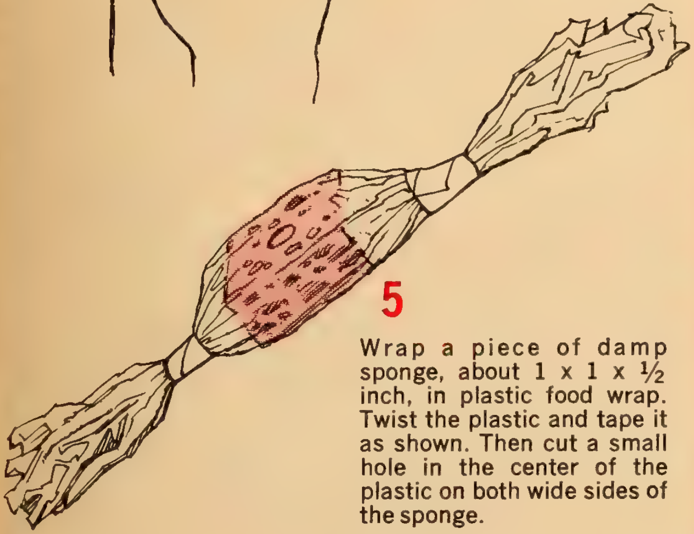
By this time the fly food should be dry. Cut out a scrap of paper with one of the cakes of food on it. Fasten it with tape to the inside of the box.

Now cover the bottom and the top of the carton. Use a piece of plastic food wrap, or any transparent plastic, to cover the bottom. Pull the plastic around the bottom edges of the box and fasten it smoothly with tape *(see Dia-*



4

After taping a food pad into the carton, tape clear plastic over the bottom hole.



5

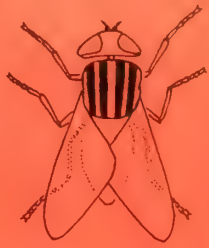
Wrap a piece of damp sponge, about 1 x 1 x ½ inch, in plastic food wrap. Twist the plastic and tape it as shown. Then cut a small hole in the center of the plastic on both wide sides of the sponge.

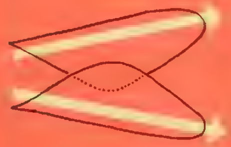
HOW TO TELL A HOUSEFLY

If you live in the country you will see many, many flies that look almost like houseflies. The reason we want true houseflies to raise is that we know what they eat and what they will lay their eggs on.

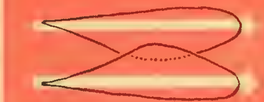
Here are some clues that will help you decide whether you have true houseflies:

- The back should have four black stripes, and not be plain black, green, blue, gold, gray, or red.





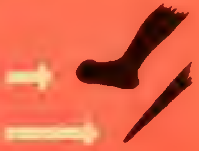
- The wings should stick out like this,



not like this.

- The tube which the fly sticks out when it eats should have a roundish end,

not a sharp point.



- The underside should be mostly light tan (not all black or gray). This light coloring should show also as you look down through the fly's wings.
- The legs should be black, not brown.

gram 4). Cover the top with a piece of old nylon stocking. A rubber band will hold the stocking in place.

The Water Supply

The flies will need a water supply. They will drink from a piece of sponge placed on top of the nylon stocking. To make a drinking hole in the stocking, paint a circle (about as big as a dime) in the center with nail polish. The hole can be cut after the nail polish has dried, and the ring of polish will keep the hole from getting larger. While the nail polish is drying you can get the sponge ready.

Cut a piece of sponge about 1 x 1 x ½ inch. Wet it and squeeze it out, then wrap it in a piece of plastic food wrap (6 to 8 inches long) as shown in Diagram 5. Gently twist the plastic as near to the sponge as you can without squashing the sponge out of shape. Then put a strip of tape around each of the twisted places. With pointed scissors cut a small hole (about as big as a pencil) in each side of the plastic as shown in the diagram. Now cut a similar hole *inside* the nail polish circle on the stocking. Be sure to leave a border of nail polish around the hole. Now fix the sponge to the top of the milk carton, as shown in Diagram 1. Make sure that one hole in the plastic is over the hole in the stocking. You can look up through the bottom of the cage to line up the holes. Your cage is now finished.

Now it's time to catch flies! An easy way to catch flies is to pop a plastic cup over a fly on a window. Slip a card under the cup, and transfer the fly to a small plastic bag. Ask someone to hold the bag upside down for you. Then push the cup up into the bag and release the fly. It will probably go all the way up into the bag. Your helper can keep the first fly trapped in a corner while you put the second fly into the bag.

Catch about a dozen flies. You will almost surely have a mixture of males and females. (Since flies can spread some diseases, be sure to wash the plastic cup and your hands well when you have finished fly catching.) If you can't find any flies around the house, look near the back door of a grocery store.

Before you put the flies in the cage, make sure that you have caught true houseflies. The box above shows how to tell a true housefly from other flies. Here are two ways to get a good look at the flies: You can hold a fly tightly, but gently, between the folds of the plastic bag, then look at it carefully; or you can chill the flies for about 10 minutes in a refrigerator. This will slow them down long enough for you to observe them closely before they warm up.

(Continued on the next page)

When you have caught enough flies, slip the end of the plastic bag over the wide part of the cone of your cage. Gather it close around the cone so that the flies can't escape. You might want to tape the bag in place while the flies walk up through the funnel into the cage. If you want to hurry them, put the cage near a bright window, making sure that the small end of the funnel is toward the light. When the flies are all in, take off the plastic bag and stuff a wad of cotton or tissue paper into the funnel so that they can't escape. (Or remove the cone and cover the flap with tape.) With a medicine dropper or spoon, wet the sponge until it is almost dripping.

The flies can live for weeks in this cage. Every day that you can, you should add a little water to the sponge. If you add too much and it drips into the cage, do not add any more water until the puddle has dried. If you go away for a few days, or if it is extremely dry in your house, cover the cage loosely with a piece of plastic. This will help keep the sponge moist. If the flies die, even though they have food and water, it is probably because they are sick or old, or because they are not houseflies and do not have the kind of food they need ■

In the next issue of Nature and Science, *the author tells how to raise and observe flies through the four stages of their life cycle. She also lists seven investigations, many of which you can do in the winter months.*

INVESTIGATIONS

Can you find out the answers to these questions about flies? Can you think of others to investigate?

1 When you put the flies into the plastic bag, or when you moved them from the bag to the cage, you were helped by the flies themselves. You saw that they usually flew or walked upward toward the light. Can you do an experiment to show which (if either) is more important—the upward direction or the light? (A cage that has clear plastic over the top as well as the bottom might be helpful. Also, a flashlight or mirror.)

2 What scares a fly? If a fly is on the outside of a window, and you are on the inside, can you touch your hand to the glass opposite its feet? How close can you bring your finger to a fly that is standing on a screen or on the stocking that covers your fly cage? Can you bring your finger closer to a fly's tail, back, side, or head without scaring it? Is there any sort of noise that will make your flies move? What happens if you blow on them? Do flies behave differently at night than in daytime, when they are naturally most active?

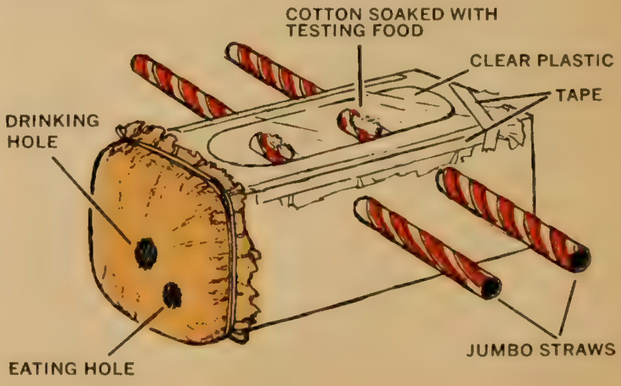
3 How many different kinds of flies live in your neighborhood?

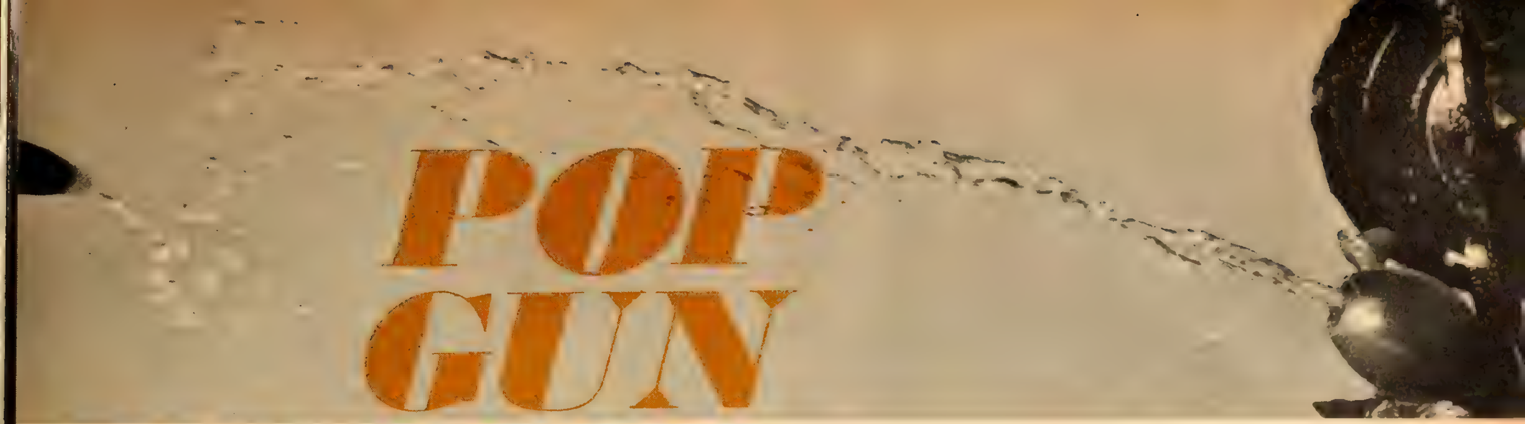
4 Collect one fly that is not a housefly. List as many differences as you can between a housefly and the other fly. If you were writing a book about identifying flies, would you be satisfied to describe a type of fly when you had looked at only one of its kind?

5 Can you show whether adult flies like some foods better than others? To help you find out, make another cage like the one described in the article, but do not put a food patch inside of it. Cut a large window in the side opposite the entry cone, and tape clear plastic over the window *(see diagram)*. In the stocking, make a food hole as well as a water hole, and tape a patch of paper with a food cake on it over the hole. With a large round pencil, punch two holes just large enough for a jumbo drinking straw in each of the sides having neither the window nor the cone entry. Cover the holes temporarily with tape.

After the flies are in the cage, remove the cone and tape that hole closed. Provide water as before, through the sponge. Before making food tests, remove the patch of fly food, cover the food hole, and let the flies have only water for about a day. Then remove the sponge, cover the water hole, and put the cage on its side, window upward.

Cut holes in the middle of two jumbo drinking straws and put a bit of absorbent cotton into each hole *(see diagram)*. Moisten the cotton of one with water, the other with milk. Uncover the holes in the sides of the cage and insert the straws, trying not to let the liquid touch the side of the cage. Do the flies prefer milk to water? Test the flies with other choices of food, such as milk and sugar water, milk and salt water, honey water and bouillon. *Remember to give them nothing but water for one day before each test.* Do they prefer water with a little sugar or with a lot of sugar in it? Food in solid form or mixed with water? Can you find out what parts of a fly are able to taste?





POP GUN PLANT

■ If you stand under a sprig of mistletoe in someone's house around Christmastime, you might get kissed. But if you stand under a tree with some *dwarf*mistletoe growing on it, you might get hit in the eye.

Dwarfmistletoe is a relative of the kind of mistletoe used as a Christmas decoration. It grows in the western and northern parts of the United States but it doesn't grow in the ground. Instead, it grows *only* in the branches of cone-bearing trees like pine trees. Its roots grow down into the branches, and it gets all its food and water from the tree, not from the soil.

Since dwarfmistletoe grows only in trees, it might die out if all of its seeds fell to the ground like acorns from an oak tree. Instead, this plant has a special way of getting its seed from one tree to the next. It shoots them, much like a popgun. Here is how it works.

Each little fruit on the plant has a tiny seed inside, where the end of the fruit is attached to the stem (*see diagram*). As the fruit ripens, the stem grows longer and curves so that the fruit hangs downward. The fruit soaks up water from the stem until the water is squeezed tightly between the seed and the inside of the fruit. When the fruit drops off the stem, the water pushes the seed out of the fruit with great force (*see photo above*).

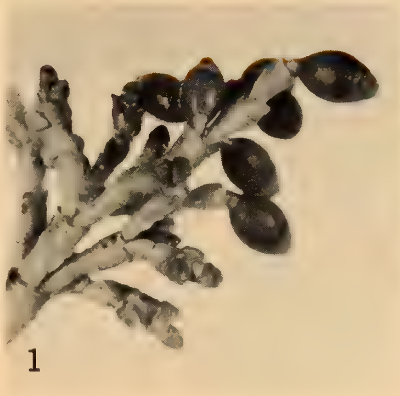
By taking several photographs just a fraction of a second apart, scientists have found that the seed leaves the fruit at a speed of about 80 to 90 feet per second, or about 60 miles an hour. The seeds are so "streamlined"—rounded at the front end and pointed at the rear—that they travel through the air like tiny, light bullets. Some shoot as far as 50 feet before dropping.

Even so, less than half the seeds ever land in another tree. And very few of these ever take root. The seeds that land in the pine needles have the best chance. The seeds have a sticky coating, and if they land in the needles they will stick there. Then when it rains, the water loosens them enough to slide down the needles to the young twigs. The seed can only send its root into soft wood (*see photo 2*).

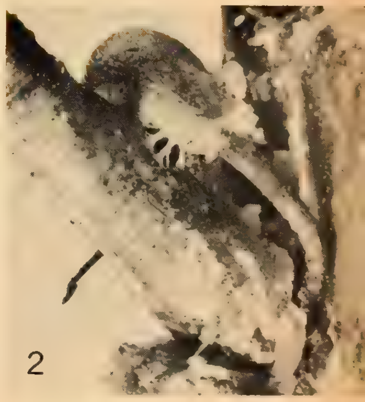
The root then develops inside the twig and two to five years later it sends a new dwarfmistletoe shoot out of the bark. When the shoot is about 2 inches long it begins to develop its own fruit and its own seeds. Then the whole process starts over again ■

PROJECT

Dwarf mistletoe is a *parasite*, taking its food from another organism. Can you think of some other plants and animals that are parasites? Do plants and animals usually die when parasites live on them?

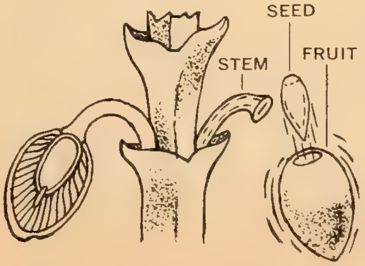


1



2

1. As the fruits of dwarfmistletoe ripen, they hang down and soak up water that presses against the seed inside. 2. This dwarfmistletoe seed landed at the base of a young twig. Its rootlet is growing into the bark of the tree.



When a mature fruit falls from its stem, the water pressure inside the fruit forces the seed out and away through the air.

This article was adapted from "Spread of a Parasite," by Frank C. Hawksworth and Thomas E. Hinds, published in Natural History, *March 1965.*

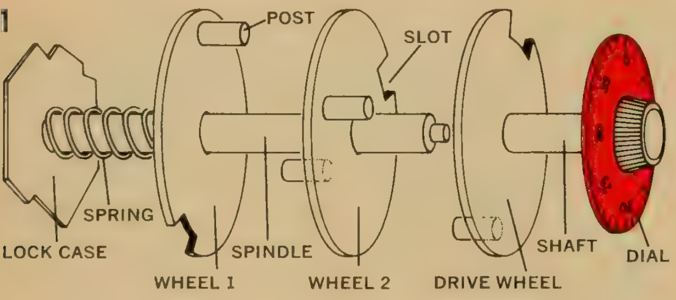
HOW IT WORKS

Combination Locks

■ A combination padlock is handy for locking your school locker or bicycle, because it opens without a key. To open it, all you have to know is the "combination"—usually a series of three numbers—and which way to turn the dial to line up the first number of the combination with a notch on the face of the lock. Here is how it works:

Inside the lock there are three small wheels. One of the wheels, called the *drive wheel,* is attached to the *shaft* so that it turns with the dial *(see Diagram 1).* The other two wheels turn freely around the *spindle.* One end of the spindle fits into the end of the shaft, the other end is attached to the lock case. (The shaft and spindle may be arranged differently in some kinds of locks.)

1

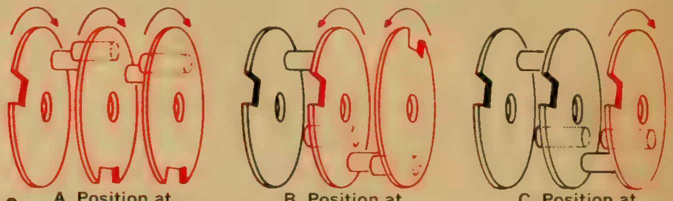


Each wheel has a slot cut into its edge. Each outer wheel has a small metal *post* sticking out from the side toward the center wheel. The center wheel has a post on each side. Each of the two "free" wheels will turn only when the post on its side is pushed by the post on the wheel next to it.

To open the lock, you first turn the dial all the way around twice in the same direction, say to the right. This brings the posts of all three wheels together so that they all turn with the dial. When you stop turning the dial at the first number of the combination, the wheel farthest from the dial is set with the slot in its edge at a certain point *(see Diagram 2A).*

Next, you turn the dial one full turn in the opposite direction (left), then on to the second number of the combination. This leaves the first wheel unmoved and turns the middle wheel so that its slot is lined up with the slot in the first wheel *(see Diagram 2B).* Finally, you turn the dial again in the opposite direction (right) to the third number of the combination. This turns only the drive wheel and brings its slot into line with the slots in the other two wheels *(see Diagram 2C).*

2



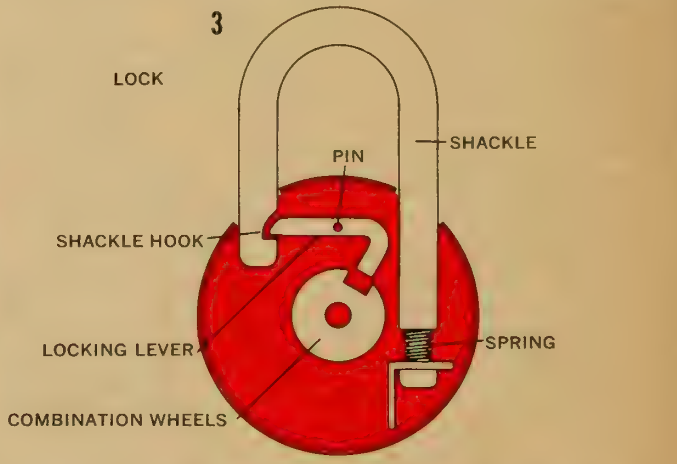
A. Position at 1st number

B. Position at 2nd number

C. Position at 3rd number

Now a tug on the lock pulls the *shackle*—the curved bar that fits through the holes on your locker and its door—part way out of the lock. As the shackle moves, a *hook* near one end pulls the *locking lever* upward *(see Diagram 3).* The locking lever rocks on a pin through its middle, pushing the other end of the lever into the slots in the edges of the wheels. This releases the hook so that the end of the shackle can come out of the lock.

3



When you push the shackle back into the lock, the hook presses the end of the locking lever downward, lifting the other end of the lever out of the wheel slots. A spin of the dial turns the wheels so that the lock can't be opened until the wheel slots are brought back into line.

A lock like this one, with 40 marks on its dial, could have 64,000 possible combinations. Can you figure out what you would have to change to make it open with a different combination? ■

This article was prepared with the advice of Sal Schillizzi, All-Over Locksmiths, New York City.

Issue 5 *November 15, 1965*

THE WAYS OF DOGS

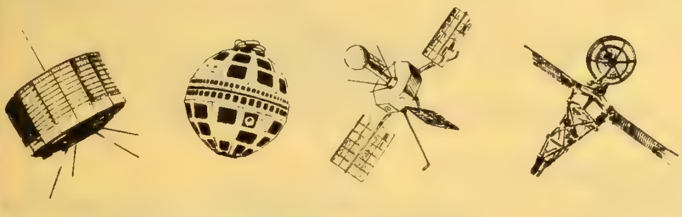
What scientists have learned recently about the behavior of man's best (and oldest) friend. Your pupils will be fascinated by this glimpse into the world of dogs as they learn how their actions can change a dog's "personality." The article presents some meaningful investigations of dog behavior and dog learning that any dog owner can try.

HOW TO TAKE MILK APART

Milk, they say, is the perfect food. It contains fat, proteins, minerals, vitamins, and carbohydrates. By very simple procedures that can be used in any classroom or at home, your pupils can make an analysis of milk—both qualitative and quantitative. This SCIENCE WORKSHOP can be used to introduce a wide range of science concepts.

WHAT'S UP THERE?

For the space enthusiasts in your class, here is an up-to-the-minute WALL CHART that summarizes the kinds of satellites in orbit and those soon to be launched, describing not only their specifications but their scientific missions in space.



MYSTERY STONES FROM SPACE

In past ages, glassy stones called "tektites" rained in on the earth (in the U.S.: mainly in Texas, Georgia, and Massachusetts), but scientists are still not quite sure what these objects are or where they came from—from the moon? From an exploded planet? From huge volcanoes of earlier ages?

HOW COLD IS COLD?

The amazing world of super-cold temperatures—below 200 degrees centigrade. In this strange world air becomes liquid, hydrogen boils, and solid matter goes into a sort of super-hibernation. Of great interest to modern scientific research, the world of way below zero is also an exciting way to explain some things about the nature of matter to young readers.

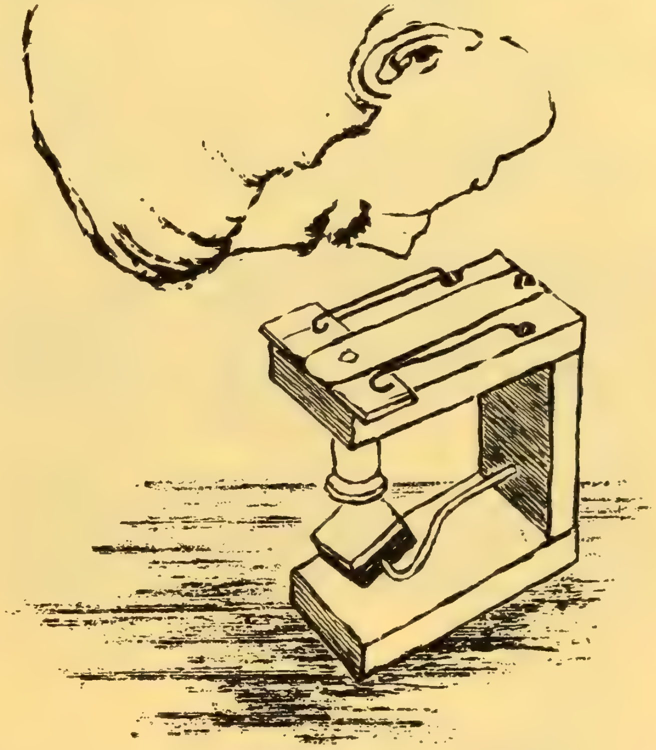
Issue 6 *December 6, 1965*

HOW HOT IS HOT?

Continuing the Roy Gallant series on the nature of heat and cold, this article delves into heat and what it means in terms of molecular agitation. It explains what happens to the molecules in a solid substance when it is heated to become a liquid, then a gas. Is there a limit to how hot (or agitated) molecules can get? Some answers to this question are suggested by the story of what goes on inside of a star.

MAKE YOUR OWN MICROSCOPE

Here is an ingenious project whereby each pupil can make a workable and useful microscope for no more than 20 cents. This article will be followed by occasional SCIENCE WORKSHOPS showing new and exciting ways to use this and other simple microscopes.



SECRETS OF THE SWIFT

A personal story of how, with the aid of children in his neighborhood, an enterprising Cornell ornithologist investigated the secretive ways of chimney swifts over a 15-year period. The article, which reveals the author's discoveries about the nest behavior and family life of the elusive swifts, also gives insight into the ways of a scientist—his ideas, actions, and frustrations in seeking knowledge.

BIRTH OF AN ISLAND

Not far from Iceland, a new island (called Surtesey after the Icelandic god, Surter) has recently risen from the sea. Already plants and animals are forming new communities, and scientists are studying the marvelous ways in which new life comes across the ocean to new land.

Issue 7 *December 20, 1965*

SPECIAL ISSUE–THE OCEANS

MAN UNDER THE SEA

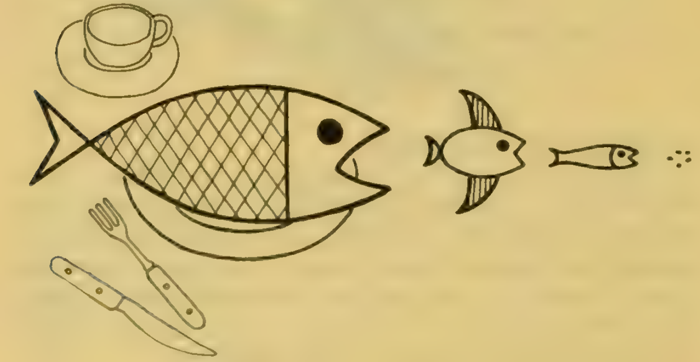
In this article by a frequent *Nature and Science* contributor, Diane Sherman, your pupils will view some of man's most recent activities under the sea, from the science of oyster farming to the efforts of Jacques Yves Cousteau to establish an underwater colony of men.

THE LANDSCAPE OF THE DEEP

The ocean bottom has its own Mount Everests, its own Great Plains. This article will look at the nature and origin of the ocean bottom and describe what scientists are learning about the history of the earth by sounding the depths and taking samples of bottom sediments.

WHO EATS WHOM EATS WHOM EATS WHOM

A richly detailed WALL CHART showing the great chain of life in the oceans—a chain that begins with microscopic plants and animals and which might end up in a whale, or on the dinner table.



HOW DOES A WAVE WORK?

From the ripples in ponds to the great destructive spectacle of the tsunami (tidal wave), all waves follow certain basic principles, some of which can be discovered by the pupil himself with simple experiments at school or home.

Issue 8 *January 10, 1966*

COLORED LIGHTS AND GREEN PLANTS

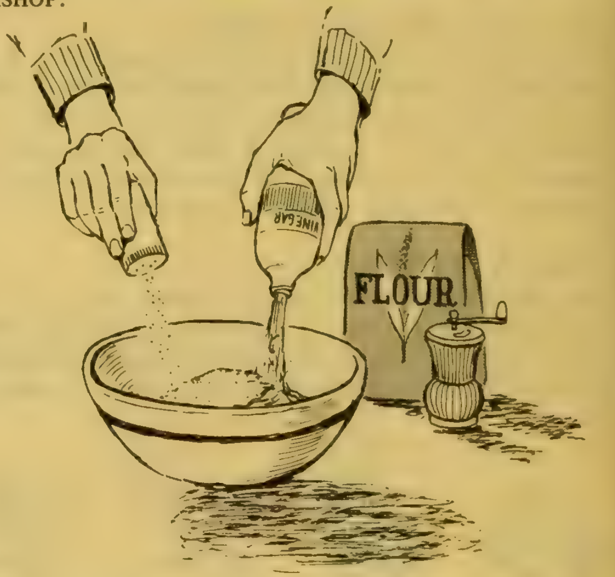
Green plants need light for growth. But what kind of light? This SCIENCE WORKSHOP written by Dr. Richard Klein, botanical consultant to *Nature and Science,* tells readers how to test the effects of colored lights on corn seedlings.

LIFE ON OTHER PLANETS

The current exploration of space makes this perennially popular speculation a timely subject for scientific consideration. Author Roy Gallant explores the solar system and beyond, showing the physical and chemical conditions that should exist if an environment is to offer any chance for the evolution of life as we earthlings know it.

MIXTURES AND SOLUTIONS

Salt, pepper, flour, vinegar. These and other everyday substances will involve your pupils in uncovering several of the basic ideas of chemistry in this open-ended SCIENCE WORKSHOP.



ALBINO ANIMALS

Imagine an all-white crow. Impossible? No, an albino. This article about strange, pure-white animals (with pink eyes) will reveal the workings of hereditary laws to your pupils.

HOW BIG ARE YOUR PUPILS?

No pun intended—we mean the pupils of your eyes. "Eyes like saucers," "her eyes lit up," "bug-eyed"—all of these expressions refer to the fact that the pupils of most people's eyes dilate when they are excited by what they are looking at. This article tells how the phenomenon was recently discovered and how pupil diameter is being used in psychological research.

P.S. We hope that your pupils' pupils will **double** in diameter each time they receive **Nature and Science** this year.

USING THIS ISSUE . . .

(continued from page 2T)

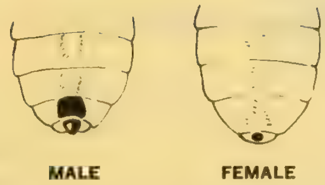
Suggestions for Classroom Use

Here are a few hints that may be helpful: In making the cage, masking tape may be easier to use than transparent tape. If a pupil has trouble placing the sponge so that no flies can escape, a second layer of stocking can be fastened over the entire top of the cage. This top stocking should have a hole through which the sponge underneath can be moistened. If some pupils fail to catch enough flies, or if there is not enough space for one cage per pupil, several children can pool their flies and work together.

Some sharp-eyed pupil may want confirmation of his guess about the sex of an adult fly. The male has a larger dark spot at the point of his abdomen *(see diagram)*. The smaller dark spot at the point of the female's abdomen is a portion of the retracted ovipositor.

Mating occurs a few days after the adult fly has emerged from the pupal case. Egg laying usually starts a week or two after emergence, but the housefly will lay eggs only on a substance suitable for the development of the larvae. (Part 2 will tell how to prepare such a substance from dried dog food – *not* the gravy-flavored kind – and dried yeast.) In this project, the keeping of flies for one week before introducing them to the maggot food increases the likelihood that at least one of the females will be ready to lay eggs immediately.

Topics for Class Discussion



You can tell a female housefly from a male by the spots on the under side of the back end of the fly's abdomen.

- *How are houseflies classified in the animal kingdom?* Insects are a class within a larger group of invertebrates called the *arthropods* ("jointed feet"). Along with other arthropods—such as spiders, centipedes, and lobsters—insects all have distinct joints in their legs (unlike such invertebrates as starfish and octopuses). Arthropods have hard, external skeletons. The skeleton is typically *molted,* or shed, at intervals, allowing the rigid parts of the skeleton to grow during a few hours of flexibility. Insects are distinguished from other arthropods by having six legs.
- *What human diseases do flies help spread?* Among the diseases which flies spread are typhoid fever, cholera, dysentery, infant diarrhea, tuberculosis, and poliomyelitis. Flies are rarely the sole means by which a disease is transmitted, and they are not known to be true intermediate hosts of any organism causing disease in man. This may be contrasted with the role of the anopheles mosquito, which is necessary for the transmission and perpetuation of malaria.
- *Why study houseflies?* By studying the life cycle and behavior of houseflies, scientists have discovered ways of controlling them. They have also gained insight into the lives of other animals.

Tips on Investigating Flies

In the course of their investigations, your pupils may exclaim in exasperation that all houseflies simply do not behave the same way. They are probably right. Even when such factors as age and sex are taken into account, the flies may have innate individual differences. Still, by testing the behavior of a number of flies, and by comparing findings with their classmates, they should be able to arrive at some general conclusions—about the housefly's reactions to light, gravity, and different foods, for example—that are reasonably valid.

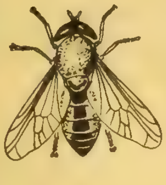
These tips may be helpful in carrying out some of the investigations suggested in the article:

Investigation 1. To test effects of light and gravity on flies, you might set the cage stocking-end down on a piece of clear plastic, slide the stocking off, and tape the plastic over the end. Hold it with one end, then the other, toward the light. In a dimly lit area, turn the cage with one end, then the other end, upward. Where do the flies go in each case? Can the flies be lured to the bottom end of the cage with a flashlight? (Be sure to replace the temporary window with the stocking and sponge before the flies run out of air!)

Investigation 3. A few common kinds of flies that can be distinguished quite easily are shown below . These books will also help in identifying dif-

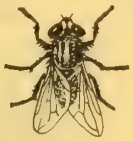
(Continued on the next page)

HOW TO IDENTIFY SOME COMMON KINDS OF FLIES

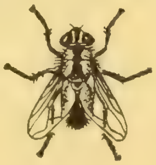


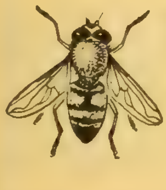
HORSEFLY
Bigger than housefly. It has a short beak and most kinds have eyes beautifully marked with iridescent colors.

HOUSEFLY
(See "How To Tell a Housefly," page 13)

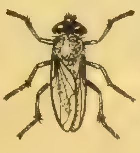


BLUE OR GREEN BOTTLE FLY
Abdomen is colored a bright, metallic blue or green.

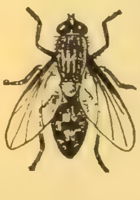




FLOWER FLY
Looks like a wasp or bee.



CLUSTER FLY
Very like a housefly, but it rests with wings overlapping in back. Space between eyes is white.



FLESH FLY
Striped and checked with silver and black.

USING THIS ISSUE . .
(continued from page 7T)

ferent species of flies: *Field Book of Insects,* by Frank E. Lutz, G. P. Putnam's Sons, New York, 1935, $3.95; *How To Know the Insects,* by Harry E. Jacques, William C. Brown Company, Dubuque, Iowa, 1947, $2.75, paper $2.25. *Insects* (a Golden Nature Guide), by Herbert S. Zim and Clarence Cottam, Golden Press, New York, 1956, $1.

Investigation 4. Some of the differences to look for are mentioned in the box, "How To Tell a Housefly," on page 13. Other distinguishing features are size, eye color, and temperament (sluggish or peppy).

15 Popgun Plant

When scientists look at the complicated "popgun" mechanism of the dwarfmistletoe, they ask: Why and how did this come about? To answer the first question, think of various adaptations of other organisms—the duck's webbed feet, the turtle's shell, the parachute on a dandelion seed. Most adaptations can be explained by one or more of the following reasons: They help the organism get its food, escape its enemies, or reproduce itself.

The "popgun" effect makes it possible for dwarfmistletoe to reproduce itself by spreading the seeds far from the parent plant. This also helps reduce competition for food between the parent plant and the plants that grow from the seeds. Exactly how the dwarfmistletoe family gradually evolved this unusual way of seed dispersal is not known.

Activities

- Have your pupils find out what other kinds of plants spread by "explosions." (They include witch hazel, sheep sorrel, and jewelweed.)
- Take your class on a hike, looking for different ways of seed dispersal, or ask a group of students to collect and prepare a bulletin board display of the different ways in which seeds are spread.

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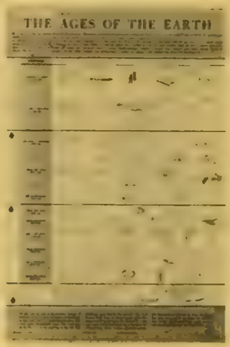

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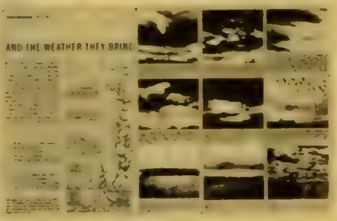

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nature and science
TEACHER'S EDITION
VOL. 3 NO. 2 / OCTOBER 4, 1965 / SECTION 1 OF TWO SECTIONS
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How Does a Fly Say "No"?

by Vincent G. Dethier

■ A properly conducted experiment is a beautiful thing. It is an adventure, an expedition, a conquest. It commences with an act of faith, faith that the world is real, that our senses generally can be trusted, that effects have causes, and that we can discover meaning by reason. It continues with an observation and a question. An experiment is a scientist's way of asking nature a question. He alters a condition, observes a result, and draws a conclusion. It is no game for a disorderly mind (although the ranks of science are replete with confused thinkers). There are many ways of going astray.

Controls and Conclusions

The most commonly committed scientific sin is the lack of proper experimental control. The scientist must be certain that the result he obtains is a consequence of the specific alteration he introduced and not of some other coincidental one. There is the case of the gentleman who had trained a flea to leap at the command "Jump!"

"Now," said the clever gentleman, "I shall do an experiment to discover where the flea's ears are located. First I shall amputate his feelers." Whereupon, the operation having been completed and the flea having recovered, the command "Jump!" was given. The flea jumped. "Ah," said the gentleman, obviously pleased, "he does not hear with his antennae. I shall now amputate his forelegs." With each succeeding operation the flea leaped on command until only the hind-most legs remained. When they were removed, the flea failed to jump. "You see," concluded the gentleman triumphantly, "he hears with his hind legs."

Of course even controls can be carried to absurd extremes as in the case of the atheistic scientist who seized upon the opportunity afforded by the birth of twins to test the efficacy of religion. He had one baby baptized and kept the other as a control.

Another common fallacy is that of confusing correlation with cause and effect. This is exemplified by the case of the gentleman who was extricated from the rubble of an apartment house immediately after an earthquake. "Do you know what happened?" his rescuers inquired.

"I am not certain," replied the survivor. "I remember pulling down the window shade and it caused the whole building to collapse."

The kind of question asked of nature is a measure of a scientist's intellectual stature. Too many research workers have no questions at all to ask, but this does not deter them from doing experiments. They become enamored of a new instrument, acquire it, then ask only "What can I do with this beauty?" Others ask such questions as "How many leaves are there this year on the ivy on the zoology building?" And having counted them do not know what to do with the information. But some questions can be useful and challenging. And meaningful questions can be asked of a fly.

A Fly Cannot Lie, but–

Between the fly and the biologist, however, there is a language barrier

(Continued on page 7T)

This article was adapted from *To Know a Fly*, *by* Vincent G. Dethier, © copyright 1962 by Holden-Day, Inc., San Francisco ($3.75; paperback $1.95), and is printed by permission of the publisher. This book for adults explains how one goes about learning how a fly works, and it presents a sound yet amusing picture of a research worker enjoying his work. It suggests many experiments that can be done by your pupils in connection with the two-part Science Workshop article on "The Fly" published in this and the last issue of *N&S*. Dr. Dethier is a Professor of Zoology and Psychology at the University of Pennsylvania.

nature and science
EYE TO EYE WITH A HOUSEFLY
A LOOK AT EYES

IN THIS ISSUE

Announcing
nature and science
RESOURCE STUDY UNITS
(see page 3T)

(For classroom use of articles preceded by ●, see pages 2T and 7T.)

● The Last of the Yahi
The classic story of Ishi will prepare your pupils for a discussion of the concept of "culture" and what sometimes happens when a primitive culture is confronted by a more complex and powerful culture.

● The Fly—Part 2
Instructions for raising and testing the behavior of maggots.

● A Look at Eyes
The eyes of animals have evolved in different ways to meet their particular survival needs.

When Is a Plant Not a Plant?
Classification is a man-made plan; nature doesn't always fit into it.

The Push and Pull of Siphons
Your pupils can find out how a siphon works by making one and trying it out in different ways, and then test their findings.

How It Works—Toilets
This common appliance uses two important technological devices: the siphon and control by feedback.

IN THE NEXT ISSUE

A special-topic issue on Exploring Life in the Past tells how to find and collect fossils and explains how scientists learn about the past from plant and animal remains.

USING THIS ISSUE OF NATURE AND SCIENCE IN YOUR CLASSROOM

PAGE 2 Last of the Yahi

Each of us—whether brought up in the Congo, in Des Moines, or in the jungles of the Amazon—has grown up with a particular set of attitudes about the world and toward other people and a particular way of living that were passed on to us by the people with whom we grew up. This learned pattern of thinking and behavior is our culture. Man is the only animal with the highly developed language needed for transmitting culture.

The story of Ishi provides a good springboard for introducing your pupils to the concept of culture and some of the problems that result when people with a simple, primitive culture are confronted by people with a more complex and efficient culture.

Suggestions for Classroom Use

Have your pupils compare the way Ishi's people lived with the way people live in our culture. For example, Yahi children as well as adults had to spend most of their time hunting and gathering food. How much of their time do your pupils and their families spend in getting (including earning money to buy) food? Do they have more time than the Yahi did to devote to other activities? Why is this so? (Our food is produced by relatively few people, using machines that do the work of many people and scientific methods that increase the yields of farming and stock raising.)

Topics for Classroom Discussion

- *Why do people in different places on earth have different cultures?* The climate, geography, and resources in a particular area determine in large part how people live in that area. Compare life in a fishing or farming community with life in a commercial or industrial city.

- *Do cultures ever change?* If a group of people is isolated from people with other cultures, and most of their time is spent in getting food and other necessities of life, they usually change their way of life very little. If food is plentiful, they will have more time to develop a more complex way of life.

If people with a simple culture are confronted by people of a more complex and efficient culture, the simpler culture may disappear (like that of the Yahi). Or the people of the simpler culture may change their way of life by borrowing ideas from the more advanced culture. This is what is happening in most of the so-called "underdeveloped" countries today.

- *Were all of the American Indians killed off by white settlers?* No, many Indians survived the invasion of their lands, and their descendants are now citizens of the United States. There are now more than half a million Indians among the population, and their number is increasing. Most of them receive government assistance, but only a few live on government reservations.

An excellent source of information about the Indians today is a pamphlet, *Answers to Questions about the American Indian,* published by the U.S. Bureau of Indian Affairs (available for 20 cents from the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402).

PAGE 6 The Fly—Part 2

By watching and working with housefly maggots (larvae), your pupils may come to appreciate the great differences which some insects show as they go through the various stages of development. The fly's "complete metamorphosis" (life cycle consisting of egg, larva, pupa, and adult) is characteristic of many insects (moths, butterflies, beetles, bees, wasps, ants, and mosquitoes, for example). The growing time in this type of life cycle is during the larval stage; insects do not grow as adults. (All insects do not go through the same type of metamorphosis [*see "The Larger Orders of Insects"* N&S, *July 1964*].)

Maggots have no wings, legs, nor eyes. Their most conspicuous feature is the dark, beak-like structure at the front. This is formed by several *sclerites,* or hard pieces containing *chitin,* which is the same material that gives hardness to an adult insect's skeleton. The front sclerite of the large maggot aids in movement. Each larva has two or more (depending on the stage) *spiracles,* or breathing holes. In the third stage larva each of the posterior spiracles is surrounded by a chitinous ring. These are the spots that look like two black eyes at the wrong end.

Suggestions for Classroom Use

It may be desirable to mix maggot food in large amounts. Depending on the size of the breeding jars, it will take about ¼ to ⅔ cup of dry dog food for each jar. For 20 jars use about 10 cups of dry dog food and two packages of yeast. The dog food and the yeast may be moistened with cold water; allow extra time for the water to soak in. Add maggot food to breeding jars to a depth of about 1½ to 2 inches.

After eggs or larvae appear, they can be divided among several jars, one jar for each pupil. Anyone who seriously claims to find the project esthetically unattractive may be encouraged to tend just a few larvae in a pill bottle half filled with maggot food.

If sawdust or sand are not readily available, Cat Litter, purchased from a grocery store, makes an excellent dry layer over the maggot food.

Sometimes when exceptionally active maggots bore through the cover, and more layers of stocking are added, it is harder to see the maggots clearly. For better visibility, the breeding jar can be set inside a larger jar, with a stocking lid on the outer jar and no lid on the inner one. Maggots may then pupate between the two jars. A wad of paper wedged between the two jars will keep the inside one from rattling around.

Topics for Class Discussion

- *Where do flies live?* Except for

(Continued on page 7T)

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CONTENTS

A Pond in Your Living Room gives advice on buying or making a small aquarium, tells how to stock and maintain it, and suggests ways to study the behavior of aquarium animals.
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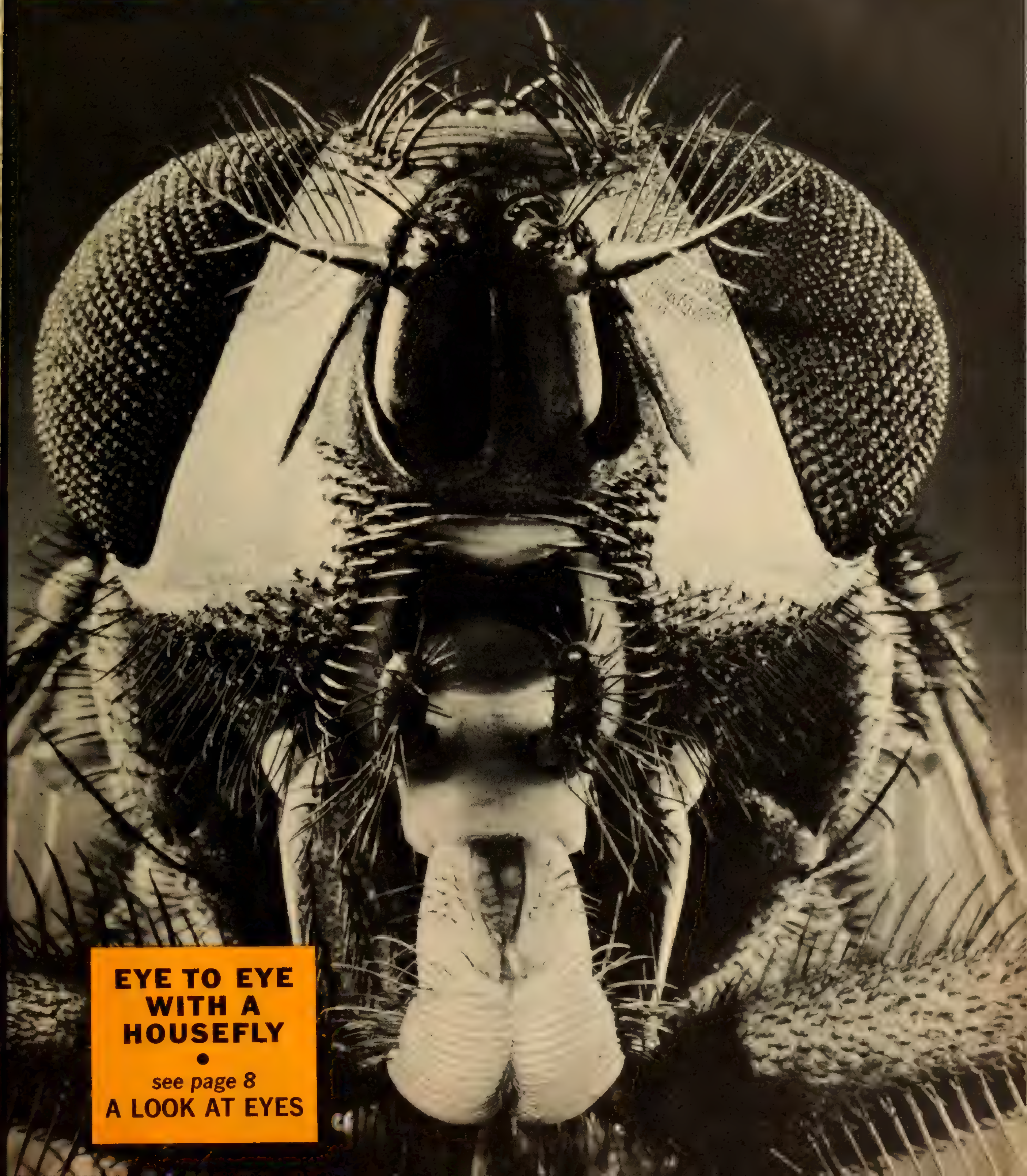
nature and science

VOL. 3 NO. 2 / OCTOBER 4, 1965

If you had always lived in the wilderness, what would surprise you most about a modern city?

see page 2

THE LAST OF THE YAHI



EYE TO EYE WITH A HOUSEFLY

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A LOOK AT EYES

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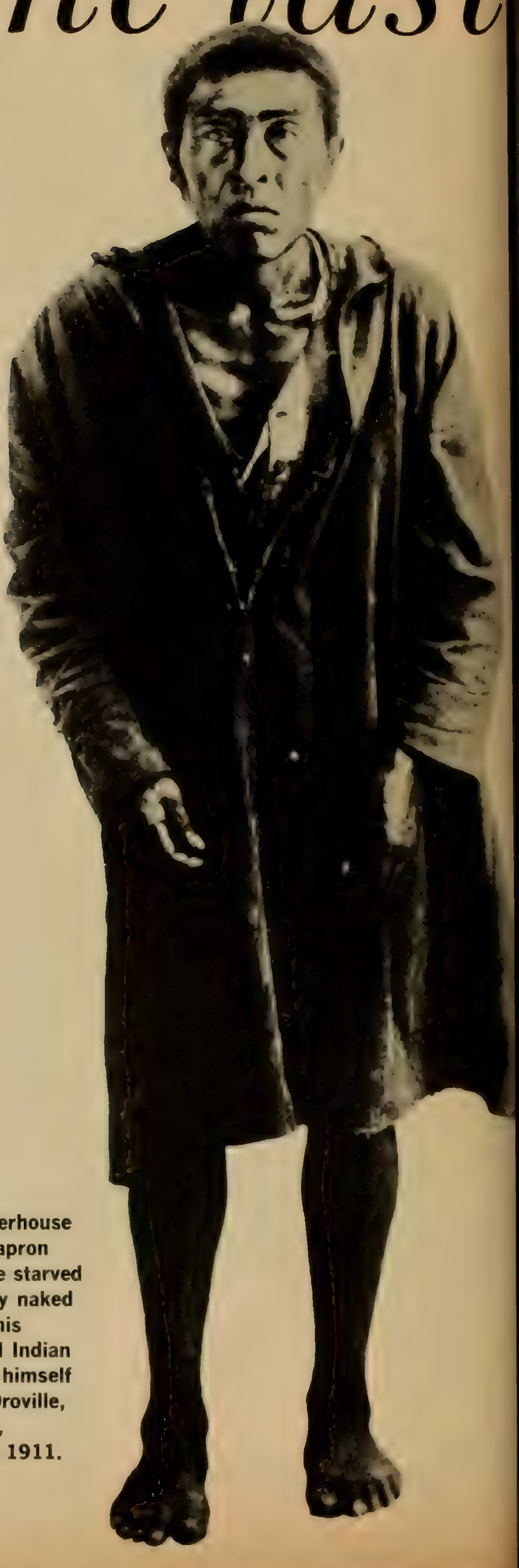

A slaughterhouse worker's apron covers the starved and nearly naked body of this frightened Indian who gave himself up near Oroville, California, in August 1911.

f the YAHI

by Jean Le Corbeiller

How our world appeared to an Indian who had lived all of his life in the wilderness of northern California.

■ What would it feel like to be brought up in the Stone Age and then suddenly be confronted with twentieth-century western civilization? Not a very likely idea, you may think —a science-fiction sort of thing.

Yet, in the early morning hours of August 29, 1911, just such a thing happened. The place was Oroville, a small town in the hills of northern California *(see map)*. Oroville was founded in 1849, when thousands of men trekked over the Sierra mountain passes in search of gold.

As white campers and settlers began pouring in from the East, the Indians got scarcer. Some of them settled on the edges of the white world and adapted as best they could. Others took to the hills. White hunters and gold prospectors sometimes ran into them and shot them. Sometimes the Indians raided white settlements and army troops were sent to put them down. By 1911, if you had asked people in Oroville whether any wild Indians remained, they would probably have said no.

But it *was* an Indian who appeared on that August morning in 1911—a wild Indian. After days of starvation and wandering, he had reached a slaughterhouse at the edge of Oroville. The workmen gathered round him. He was speechless with fright, so thin that the skin clung to the bones of his face and shoulders. He was practically naked and had a wild, hunted look in his eyes. The men gave him a canvas apron to wear *(see photo)* and the sheriff put him in jail.

What tribe was the Indian from? There was no way of asking him. He didn't understand English, or Spanish, or any of the Indian languages that visitors to his cell tried out on him.

Solving the Puzzle

News of this strange prisoner finally reached a group of men in San Francisco at the University of California. These men were anthropologists, who study the ways of life of the people in different parts of the world. One of them was Professor A. L. Kroeber. Kroeber had a young man on his staff named T. T. Waterman, who had explored traces of Indian life in the country north of Oroville two years before. Waterman took the first train to Oroville.

When the young scientist arrived at the Indian's cell, the man was sitting on the edge of a wooden cot. Waterman sat down beside him. To find a way of talking with the Indian, Waterman was counting on two lists of words that he had collected from the last survivors of two extinct tribes of Indians who had lived some 60 miles to the north. He spoke the words, one by one, watching the Indian's reactions. The man wasn't recognizing a single word. Then Waterman came to the word *siwini*, "yellow pine," and to show what it meant tapped the side of the pine cot with his hand. The Indian's face lit up. Waterman said the word again, and this time the Indian took up the word himself, saying *"siwini! siwini!"* and slapping the side of the cot.

Contact had now been made. But contact with whom? By the time the man had recognized several other words from his meager lists, Waterman was beginning to "place" him. The words he had been trying out were from two closely related dialects of the Yana Indian language—Northern Yana and Central Yana. He realized that neither of these was exactly right, but hadn't there been other Yana dialects? There had once been Southern Yana, and there had been Yahi. The traces of Indian life that Waterman had looked into two years before had been in Yahi territory. He now realized that the man was a Yahi—the last of the Yahi.

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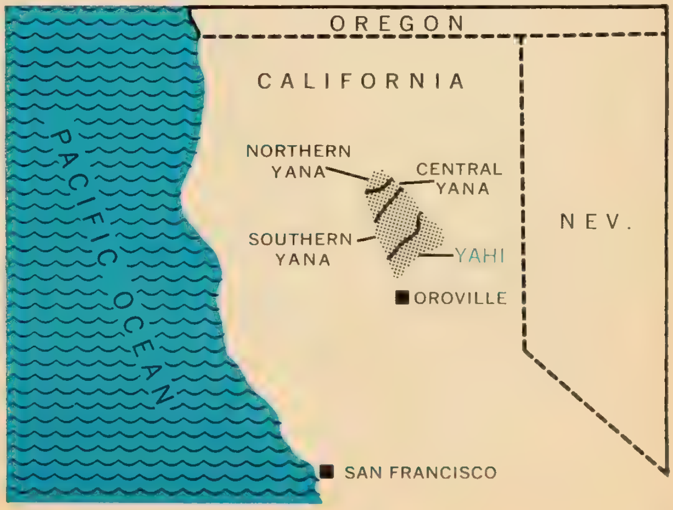


For Waterman this was an exciting discovery. It opened a window on forms of Indian life that he had thought were forever beyond his reach. But for the Indian the occasion had a more personal meaning. Only a few mornings earlier, he had been surrounded by white settlers with murder in their eyes. Hadn't these *saltu*—"Other Beings," as he called whites as a group—caused the death of every member of his family? Yet here was this earnest young man with a mustache not only talking to him as a friend, but saying words he had not heard for years.

"Are You a Yahi?"

One day, in return for the hundreds of little questions Waterman had been putting to him, the Indian asked Waterman one big question: *I ne ma Yahi?* "Are you a Yahi?" Waterman knew that this man knew that he, Waterman, was not a Yahi. So the question really meant something else. Waterman thought for a second, then said, yes, he was a Yahi.

Ishi, as the Indian came to be called, wore clothes like those of his new friends. But he did not wear any shoes, because he liked to feel the earth as he walked.

Now the two men were friends. The Bureau of Indian Affairs gave its permission for the Indian to be let out of jail. On September 4 he walked with Waterman down Oroville's main street to the railroad station. He wore clothes now, but not shoes—he liked to feel the earth as he walked.

When the train came rattling down the tracks, the Indian thought it was a great, black devil. He slipped behind a cottonwood tree to watch. The great devil seemed well behaved. People stepped out of its sides, others got on. The Indian and Waterman climbed aboard. The train, and then a ferry boat, took them to San Francisco, where they traveled by trolley car to the Museum of Anthropology.

The Indian was introduced to Professor Kroeber. The two liked each other immediately. From then on, Kroeber was The Chief (pronounced *cheep*—there's no *f* sound in Yahi). The Indian, too, would need a name. What *was* his name?

No one would ever know. In his tribe no one spoke his own name. Kroeber decided to give him a new name: *Ishi*, the Yana word for "man." Ishi accepted the new name. It was clear that he really considered it to be his name, because the word "Ishi" never crossed his lips again.

Ishi's New World

Waterman took Ishi to see the Pacific Ocean. It wasn't the ocean that impressed Ishi; it was the crowds on the beach. He had never seen so many people together. During most of Ishi's life, there were only a handful of Yahi Indians alive. He could recall a few times in his youth when all the Yahi gathered together on fall days to harvest acorns. But there were no more than 40 or 50 people together even then. They lived by hunting small animals and gathering nuts and roots. Even a large area of land provided food for only a few families. Ishi did not know about the farms and ranches that produce food for such large groups of people in our civilization, but the fact that so many people could live together in one place impressed him even more than, for example, automobiles. (To Ishi, an automobile seemed such a supernatural thing that there was no point in trying to understand it.)

Not that our twentieth-century gadgets didn't impress him at all; flush toilets, in particular, fascinated Ishi. Doorknobs were an endless source of wonder to him. Matches were pure magic, and a powerful convenience. Then there was glue. As soon as he discovered glue, he found it useful for feathering arrows.

Ishi continued to do many of the things he had done in his former life. He made bows and put together his own arrows. He made arrowheads by skillfully chipping off flakes from pieces of obsidian (a natural volcanic glass) or from pieces of the blue man-made glass of Bromo-Seltzer bottles. His great companion in archery was Dr. Saxton Pope, whom Ishi called "Popey." Pope worked in the hospital next door to the museum, and he was Ishi's doctor. The two of them often went shooting in nearby parks.

Ishi had a hard time learning to speak English. "Popey" spoke no Yahi, and neither Kroeber nor Waterman could put words together in Yahi or the other Yana dialects. They got some help, though, from another anthropologist named Edward Sapir, whose specialty was languages.

Language was not the only problem in finding out about Ishi and his people. What had happened to them during Ishi's lifetime was too painful for him to discuss it with Waterman or "Popey." But as Ishi slowly grew more sure of himself and his new friends, he sometimes revealed bits of information about his past. Waterman also gathered information about the Yahi from the accounts of white settlers who had first entered the Yahi area. By 1918, he had put these bits of information together into a description of what probably had happened to Ishi and his people. (In 1961, Professor Kroeber's wife used Waterman's material and some more information which she had found to write a fuller and truer account of Ishi's people.)

How Ishi's People Died Out

When Ishi was first brought to San Francisco, his doctor, "Popey," had examined him and decided that Ishi had been born between 1860 and 1862 and was a little more than 50 years old.

Throughout the early 1860s new settlers were pasturing their cattle and hunting in Yahi territory. The Yahi found their small territory getting smaller each year. They sometimes killed white settlers, but usually they just raided their cattle and stole supplies. Groups of settlers then went out and killed as many Indians as they could find–sometimes 30 in one expedition. The Yahi population was reduced to between 13 and 16.

Those that were left saw that this might mean the end of their tribe. They decided to go into hiding. Ishi was then a growing boy. From 1872 to 1884, no sign of Yahi life ever came to the attention of the outside world. But the Yahi forgot their caution after 1884 and started to steal from deserted cabins again. By 1894, when they took refuge in some very rough country, only five were left.

The survivors were Ishi, his mother, a young girl, and two men–one old, one slightly younger. The younger man died sometime between 1894 and 1906. The girl was either Ishi's sister or a first cousin, which was the same as being a sister according to Yana customs. So there was no generation after Ishi's.

In 1908 a party of engineers inspected the area. Two of them saw an Indian spearing salmon with a harpoon. It was Ishi. The next morning they found the Yahi hideout. Ishi's mother was there, and his sister and the old man were seen scurrying away. That night, Ishi carried his mother away to safety. Ishi never saw his sister or the old man again; he guessed that they had died soon after, as his mother did. For the next three years, until he gave himself up at Oroville, Ishi was entirely alone.

Ishi in His Own World

In the first days of May 1915, an odd expedition took off for the Yahi homeland. Its members were Ishi, "Popey," Pope's 11-year-old son Saxton, Jr., Kroeber, Waterman, and a rancher from the region, who brought along his son and a half dozen saddle horses and pack mules.

After a few days in the familiar hills and canyons, Ishi felt at home again. He knew *everything* about the region: which plants were good for food, which for medicine; where to find shelter in a storm; how to stalk a deer or call rabbits; which streams were drinkable, which not; how to skin a deer; which wood to use for bows; how to cross the rapids of Deer Creek; how to make a harpoon by binding prongs made of bone to the shaft.

Ishi guided his friends to the spots where the massacres of the 1860s had occurred. He also took a close look at all the places where any surviving Yahi might still be hiding out, and decided that he was the last of his people.

The party stayed in Yahi country for an entire month. Ishi's friends had never seen him so happy. But the following December he came down with a cough and a fever, and in March 1916 he died, of tuberculosis. The anthropologists had been deeply affected by his presence among them. Waterman, who had come to value Ishi as a friend, wrote: "He convinced me that there is such a thing as a gentlemanliness which lies outside of all training, and is an expression purely of an inward spirit. . . ." ■

If you would like to read more about the story of Ishi, look in your library or bookstore for **Ishi, Last of His Tribe,** by Theodora Kroeber, Parnassus Press, Berkeley, Calif., 1964, $3.95.

Ishi made this harpoon when he returned to the Yahi homeland in 1915 with his friends. He showed them how he had been able to survive for so many years in the wilderness.

THE FLY

PART TWO

SCIENCE WORKSHOP

How to raise, care for, and do experiments with these fascinating household pests.

by NANCY KENT ZIEBUR

Part 1 of this two-part SCIENCE WORKSHOP *appeared in the last issue of* Nature and Science. *It told how to make the fly cage with breeding jar and how to catch flies.*

■ If you did everything described in Part 1 of this article (*see* Nature and Science, *Sept. 20, 1965*), you should now have a cage of lively flies. A few of the flies you caught—old ones or sick ones—may be dead by now. If some did die, try to catch a few more, so that you have at least a dozen lively ones.

Within about a week after the flies are caught and caged, they should be ready to lay eggs. Houseflies lay eggs where yeast is growing. The eggs hatch in about a day, and the *larvae* (maggots) crawl out of the eggs and eat the yeast. In the "wild," common places where flies find yeast are on garbage and manure. But you can grow your own yeast on dog food. You will need dried dog food, such as Purina Dog Chow (do not get any of the gravy-flavored dog foods).

Put about 1½ inches of the dried dog food into the glass breeding jar that fits your cage. (If your jar is quite small, make it only one-third full.) After measuring the amount, pour the food out again into a small bowl and add just enough hot water to cover the pieces. Let it stand for 10 minutes or more. While you wait, mix ¼ teaspoon of dried yeast and about ½ teaspoon of warm water, and let this stand. When 10 minutes are up, pour off any of the water that has not soaked into the dog food. Now sprinkle the moistened yeast on top of the dog food and mix gently. Spoon the food back into the breeding jar. Do not pack it down. This mixture is your maggot food.

Now you are ready to attach the breeding jar to the cage. To do this, place the cage on a piece of cardboard. Have a helper hold the cage steady while you carefully take off the tape that holds the bottom plastic on. Slide the plastic out without lifting the cage from the cardboard *(see Diagram 1)*. Place the cage and cardboard over the jar of maggot food so that the hole in the bottom of the cage is lined up right over the jar. Now have your helper pull the cardboard away, and quickly press the cage onto the jar. Tape the cage to the jar *(see Diagram 2)*, and if there are cracks, seal them with tape. The flies can now lay eggs on the maggot food. When the temperature is between about 80° and 90° F, the flies will lay lots of eggs. In cold weather try to keep your flies just near enough to a radiator.

Watching for Larvae

Housefly eggs are white and are shaped like hot dogs. They are about as long as a pinhead is wide. The flies will lay their eggs in cracks and between chunks of the maggot food. Because the eggs are so small, and are usually well

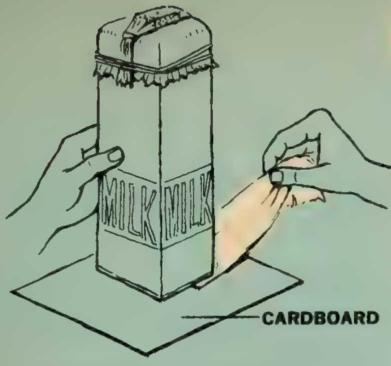
INVESTI

1. On a warm day, put a jar of fresh maggot food outdoors. After a day or two cover it with a double layer of nylon stocking and put it where you can watch for larvae. How many different kinds of flies eventually appear?

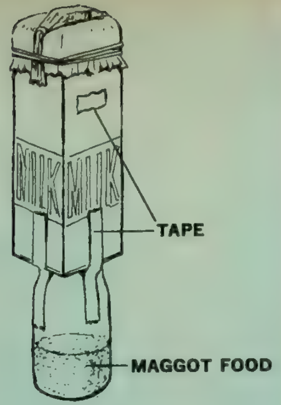
2. Flies will lay eggs on a small patch of special food and produce *clumps* of eggs that are easy to see. To prepare this special food—"fermenting maggot food"—simply let some regular maggot food stand for two to four days in a jar tightly covered with plastic. Next, put a spoonful of fermenting maggot food onto a piece of plastic. Remove the sponge from the fly cage and turn the cage upside down so that the hole in the stocking is against the food. After one day look for eggs on the patch of fermenting maggot food. If there are none, repeat the whole procedure after about a week. The fermenting maggot food can be kept covered in the refrigerator.

3. What happens to maggots if their jar is covered tightly with plastic for a long time? How many different explanations of the results can you think of? What experiments would help you choose between the different explanations? You may wish to divide your larvae among several jars. Prepare new jars of fermenting maggot food (see *Investigation* 2), and add the larvae.

4. When a jar of maggots is put in a warm, sunny spot, the maggots usually are more active than when they are in a



REMOVING PLASTIC WRAP FROM BOTTOM OF FLY CAGE



FLY CAGE WITH BREEDING JAR ATTACHED AND TAPE COVERING HOLE FOR ENTRANCE CONE

This wax model shows in detail the body of a housefly maggot. The head is at the pointed end and the small bumps serve as "legs."

hidden, you may not see them at all. *(See Investigation 2.)*

The first sign of life in your maggot food will probably be some mold. Mold usually forms in two to four days. At about the same time, or a little sooner, you should be able to see some small larvae *(see photo)*. You may now remove the jar from the box. Do this out of doors if you don't want to keep the adult flies in the cage. If you want to keep them, use the cardboard slide again and cover the bottom of the cage again with plastic food wrap.

Cover the maggot jar with two thicknesses of nylon stocking held on with a rubber band. If there are enough larvae they will destroy most of the mold. If a week goes by and you still don't see larvae, but lots of mold, empty the jar in the toilet. Prepare a new mixture of maggot food in a new jar, set the cage of flies over the jar, and try again. (Don't try to wash out the old jar. It is very hard to clean it well enough to remove all traces of the mold.)

The larvae grow very quickly in a warm room. In a week they may be half an inch long. To get a good look at a maggot, fish one out with a twig or pipe cleaner and put it on a damp paper towel. Can you see how it moves?

The maggots usually crawl up the side of the jar as the maggot food becomes wetter. When this happens, add about ¼ inch of sand, sawdust, or crumbled dried leaves to the jar. If a maggot goes all the way to the top and burrows through one layer of stocking, add a third layer of stocking. Always keep two layers ahead of the maggots.

But you may want the maggots to climb more so that you can see them better. Remove the stocking and make the jar airtight with a cover of plastic food wrap held on with a rubber band. In about an hour the maggots will start climbing. Put the stocking cover back on after you have finished watching the maggots. Why do you suppose this makes the maggots climb?

Watching for Pupae and Adults

About a week after the maggots first appear, they will move out of the moist layers of the food to the dry, top layer and turn into *pupae (see diagram in Part 1)*. The pupal cases are about ⅜ inch long. If you watch them carefully you will see them turn from yellow to brown. Within the pupal case the pupa changes into an adult fly.

While the pupae are changing, you may leave the pupal cases where they are or put them into another jar. Be sure to keep the jar covered! Hatching will start in about two weeks. The newly hatched flies can be used to fill another feeding cage. In this way you can keep your fly investigations going all winter ■

GATIONS

cool, dim room. Can you tell whether the maggots are responding to the light, or to the heat? Are there other possible explanations? What about the effect of the light or the heat on the yeast?

5. Do maggots respond to different substances that they meet? Dampen two paper towels. On one towel sprinkle a line of sugar to form a circle. On the other make a circle of pepper. Put a few maggots into each circle. Do the maggots crawl out of both circles right away? Try some other foods and chemicals. If you wish to test a liquid, such as insect repellant, dip a piece of string into the liquid and arrange it to form a circle on a damp paper towel. For comparison use a circle of string wet with water.

6. What animals eat flies and maggots? Try feeding maggots to a pet bird, turtle, fish, or mouse. If there is a place near to you where sparrows or pigeons gather, see if they will eat maggots. Will they eat pupae? (Uneaten maggots and pupae should be destroyed—by squashing or drowning in soapy water—lest they become adults.)

7. At which stages in its life cycle do you think a fly can best resist cold weather? Try keeping flies, eggs, maggots, or pupae in a refrigerator, or in a freezer, for an hour, a day, a week or two. You can try keeping them outdoors if the weather is cold. Are they killed? If you try this experiment, be sure to keep part of your living stock at room temperature for comparison.

a look at eyes

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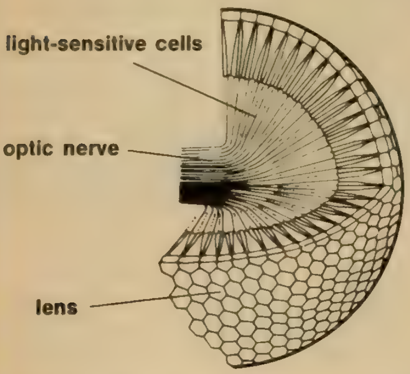
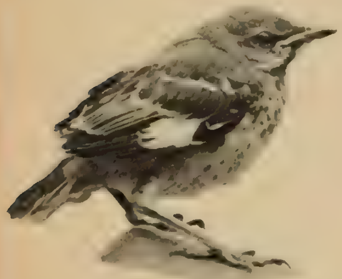
COMPOUND EYES



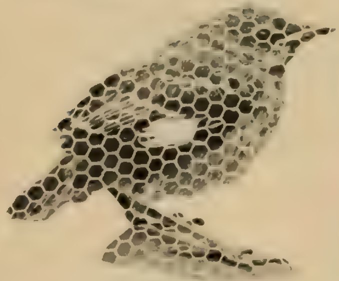
cutaway view of an insect's compound eye

Most insects have a pair of compound eyes, made of many tiny eyes packed together. Each of these small cone-shaped eyes has a lens and sensitive cells that connect with the optic nerve that runs to the brain *(see diagram)*. Each eye "sees" a different part of a scene. Compound eyes are especially good for detecting motion, because the same part of an object is seen by eye after eye as the object moves along.



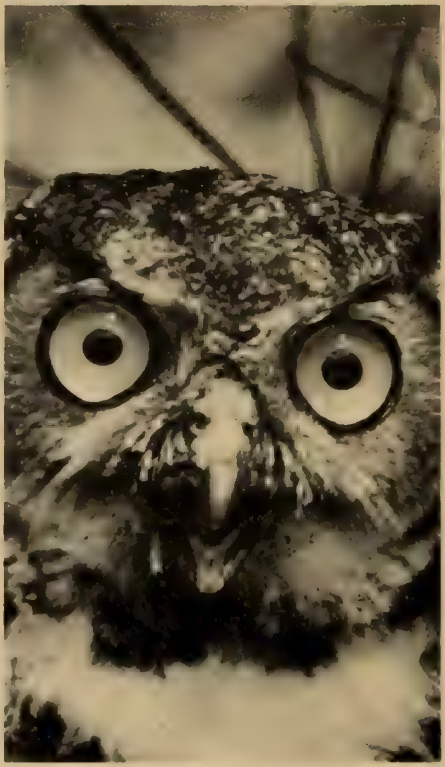
what a human sees

what an insect may see



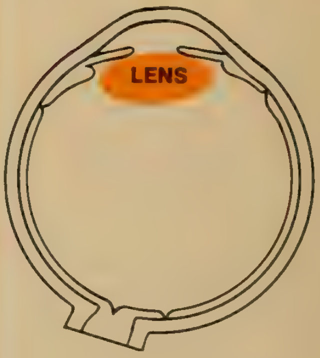
These diagrams show a bird, as humans would see it and as an insect might see it. The human eye has a lens that can focus an image on millions of sensitive cells. This gives a clear, detailed picture in the brain. What an insect sees depends mostly on the number of tiny eyes that make up its compound eyes. A dragonfly, with 28,000 small eyes in each of its compound eyes, can see well enough to catch flying mosquitoes. Some ants, however, have compound eyes made of just six smaller eyes. They probably see only vague shapes.

HUNTERS' EYES

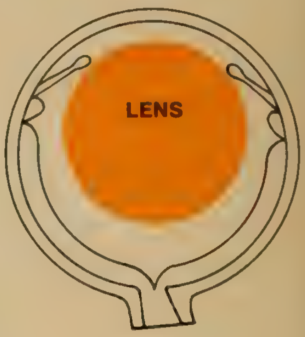


Hawks, eagles, and owls have eyeballs as big as humans', with many millions of sensitive cells packed close together in their eyes. Their vision is eight times "sharper," or more acute, than that of humans. They can see distant objects that we cannot, and they can see near-by objects in more detail than we can. Since most birds have many color-sensitive cells in their eyes, they probably see colors about as well as humans do.

EYES FOR THE NIGHT



eye of human, a day animal

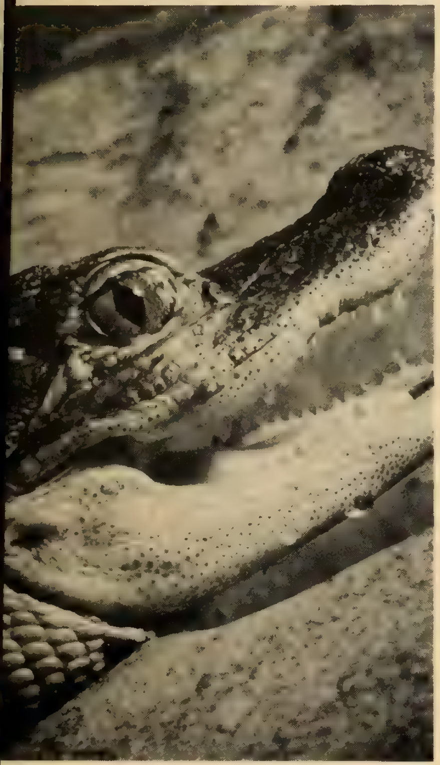


eye of house mouse, a night animal

Animals that are active after dark have many cells in their eyes that are sensitive to dim light. They don't see colors very well. Such animals also have large lenses and lens openings which help them to see at night.

**dog see colors as we do? Can a bull see red? Sight takes place in
brain, so we can never know for sure just what an animal sees.
y studying the life of an animal and examining the parts of its eyes,
n make good guesses at what the animal sees.
ample, we know that the eyes of dogs and bulls have few cells that
e to color. These animals apparently see a world of black, white,
of gray—like the photos on these pages. The stories about bulls
ging people who wear red aren't true. In fact, scientists have dis-
t bulls pay more attention to white than red, and bulls are attracted
ering object, whatever the color.
hotos and diagrams on these pages show some of the amazing
nimal eyes. The captions tell something about the animal's life
ts of its eyes—clues to the way an animal sees the world.**

EYES FOR SUNNING



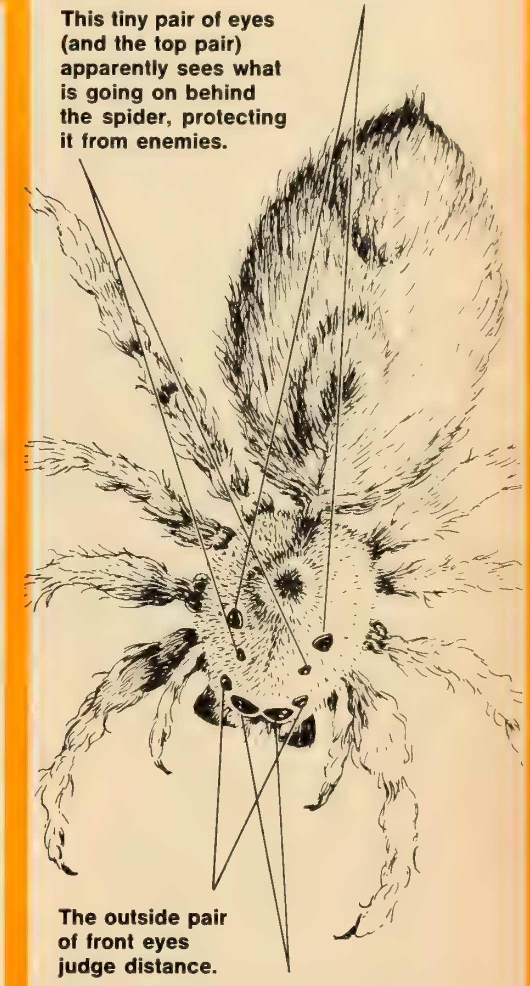
Some night animals lie in the sunshine, or bask, during the day. The eyes of these animals are so sensitive to light that they must be protected from bright sunlight. Many of them have eye openings (pupils) that narrow to a slit. Such pupils let in less light than round pupils. Animals with slit pupils include crocodiles, many kinds of cats, and many snakes.

EYES THAT GLOW

The eyes of some animals glow in the dark when a light is shined on them. This eyeshine is caused by a mirror-like layer behind the eyes' light-sensitive cells. Any light that escapes the sensitive cells is reflected back to them by this "mirror." Some of the light is reflected out of the animal's eyes and this is the eyeshine you see in raccoons, cats, deer, and other night animals.

A "TEAM" OF EYES

Jumping spiders seem to use their top pair of eyes to locate prey. When these eyes see an insect move, the spider turns so its four front eyes face the prey.



This tiny pair of eyes (and the top pair) apparently sees what is going on behind the spider, protecting it from enemies.

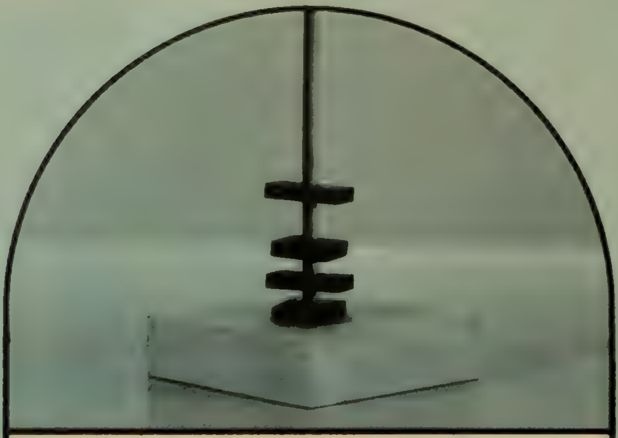
The outside pair of front eyes judge distance.

The big central pair of eyes have muscles that help bring the insect into focus.

Most spiders have eight simple eyes, but the eyes vary in size and arrangement. Spiders that hunt their food have better sight than those that build webs and wait for their food to be caught. This drawing shows the arrangement of a jumping spider's eyes, and the labels tell how the eyes are probably used to spot an insect, find its range, and to aim the spider's leap.

BRAINBOOSTERS

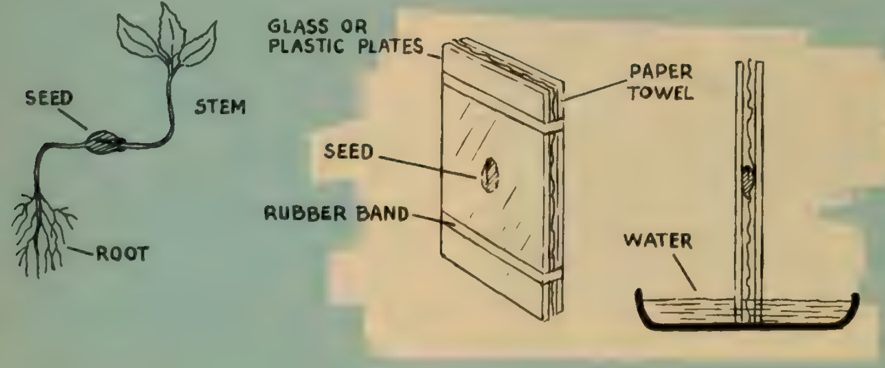
prepared by **DAVID WEBSTER**



MYSTERY PHOTO

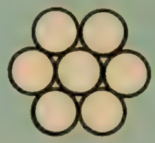
The photograph shows some ring magnets with a stick running loosely through the holes in the magnets. What do you notice about the spaces between the different magnets? What causes this?

Can you do it? Can you make a seed grow like the one pictured below? To grow a seed so you can see it, put the seed between two pieces of plastic or glass *(see diagram)*. When the "seed sandwich" is set into water, the paper towel soaks up the water and makes the seed sprout. Usually the stem grows straight up and the root straight down. What can you do to your seed to make its root and stem bend?



For science experts only... Why does popcorn pop when it is heated?

Fun with numbers and shapes... Six pennies can be placed around a seventh penny. How many quarters can be arranged around another quarter? Guess before you try. How many dimes can be placed around a quarter?



What would happen if... you put your hand inside a plastic bag and held the bag closed at your wrist for five or 10 minutes? Try it.

Answers to Brain-Boosters in last issue

Mystery Photo: The fork-shaped object in the mosquito cage is a tuning fork. Just before the photo was taken, the fork was struck with a little hammer so it would make a sound. Male mosquitos are attracted to the sound, since it is about the same tone as the noise made by the wings of female mosquitos.

Can you do it? If you pull slowly, the top string will probably break. If you jerk the string, however, the bottom string usually breaks.

What would happen if...? The gears in sets A, B, D, E, G, and H would turn. Those in the other sets could not be moved. Can you see anything the same about the sets of gears that do not move?

Fun with numbers and shapes: To find the thickness of a newspaper page, fold the page into a little wad. Then measure the thickness of the wad and count how many thicknesses of paper it contains. By dividing, you can figure about how thick each page is.

For science experts only: The cube would slide to the bottom of the board faster than the ball would roll down. Do you know why?

(Note from the editors: This answer surprised us, but Dave Webster suggested that we test it with a ball and a book. If you try it, make sure that the ball and the book are the same distance from the bottom and that you let both of them go at the same instant. You may have to do it a number of times to be sure of what happens.)

Question:

When is a plant ...not a plant?

by Laurence Pringle

Answer: **When it is a "plantimal." Sometimes it is impossible to tell a plant from an animal. The problem is an old one and it has yet to be solved.**

■ If anyone asked you if you could tell a tree from a dog, you would probably think he was a bit mad. One answer that you could give is that dogs don't have leaves. Another answer would be that plants don't move around. The only thing wrong with the second answer is that some plants do move around.

The seeds of many different kinds of plants are carried across continents and across oceans by the winds. So in this sense you could say that plants move about. Some plants that grow in the oceans, certain seaweeds, for example, attach themselves to the ocean floor for just a short part of their lives. They spend most of their lives drifting about, moved by the currents and the tides. The ability to move, even over great distances, then, does not divide *all* plants from *all* animals.

Certain animals on the other hand, do not move about. They stay in one spot nearly all their lives. The sponge is one such animal. It clings to rocks on the ocean floor and feeds by trapping bits of food from the water that passes through its body. Corals and other animals also live attached to rocks.

What about color? Many plants are green, or have green parts. Does this separate them from animals? No it doesn't, because there are some plants—such as mushrooms—that are not green. You can probably think of some green animals.

Can we tell *all* plants from *all* animals? This problem has puzzled scientists for many years. More than 2,000 years ago the Greek philosopher Aristotle tried to divide all living things into a Plant Kingdom and an Animal Kingdom. Like you, he found that it was easy to put dogs and trees in their proper groups. But some living things were hard to group. Unlike many scientists who lived long after him, Aristotle correctly placed sponges in the Animal Kingdom.

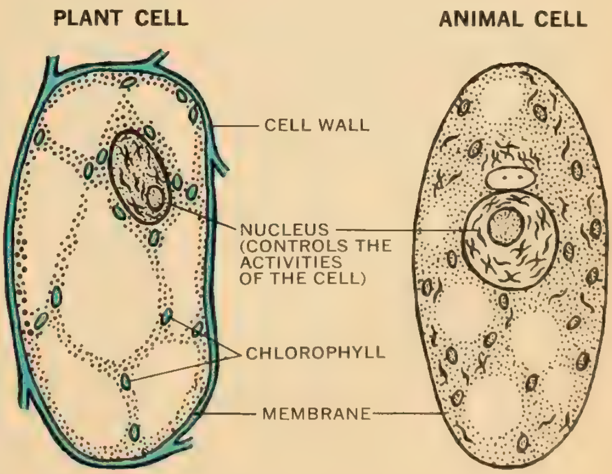
Differences between Plants and Animals

Over the years, other scientists have tried to group, or *classify,* all life into the Plant and Animal Kingdoms. In 1750 a Swedish scientist named Carolus Linnaeus felt that this puzzle could be solved. Surely, he thought, all plants must be related; they must have some things in common that make them different from all animals. Before long, scientists began to find some major differences between plants and animals.

One difference has to do with the *cells* of plants and animals. All living things are made of cells, most of which are so tiny that you can see them only with a magnifying glass or microscope. Your body is made up of about six thousand billion cells. The cells of your body—and of all other animals—are not the same as plant cells. Animal cells are enclosed by a thin rubber-like bag called a *membrane (see diagram).* Plant cells have a membrane too, but they also have a strong *cell wall* outside of the thin membrane. Animal cells do not have this tough wall.

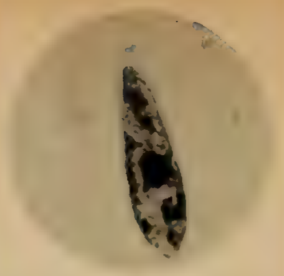
There is another main difference. Scientists have found that most plants have green matter called *chlorophyll.* Animals never have chlorophyll. All that plants need to

(Continued on the next page)

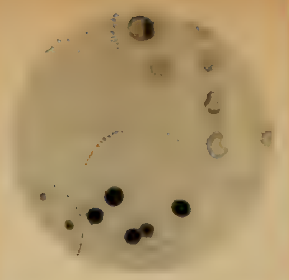


Amebas are called animals because they have no cell wall and no chlorophyll. They trap food by oozing around it.

Spirogyra cells are arranged in chains and have cell walls. Chlorophyll gives the cells a green color.



Euglena can move through water by whipping its "tail" back and forth. It usually has chlorophyll.



Volvox is a round colony of cells. Like Euglena, Volvox is like a plant in some ways and like an animal in others.

When Is a Plant Not a Plant? (continued)

make their own food is sunlight, chlorophyll, water, and certain gases which they get from the air. Since animals do not have chlorophyll, they cannot make their own food. To stay alive they must eat other animals, or eat plants. Scientists have also found that most animals have nerves and muscles. Plants do not. This is one reason why plants cannot move around the way most animals do.

As scientists learned more about plant and animal cells, they also discovered thousands of new living things. With a microscope that magnifies a drop of pond water hundreds of times, you can see many tiny plants and animals that move, grow, and reproduce. Many of these creatures are made up of just one cell. The illustrations on this page show what some of them look like under the microscope. When scientists first saw these tiny plants and animals, they tried to put each one into its proper kingdom. If you saw one of these cells under a microscope, what clues would you look for to group it as a plant or animal?

Some Tiny Plants and Animals

One of the most common of the one-celled creatures is called *ameba*. Its name means "change," because it is always changing shape as it moves about in the fresh-water ponds and streams where it lives. Amebas have a thin membrane "skin" and they trap food by oozing around it. Amebas do not have chlorophyll. Scientists have decided that amebas are animals because they do not have the cell walls and chlorophyll of plants.

Have you ever seen pond water that looks all green? The color is probably caused by millions upon millions of *spirogyra,* chains of green-colored cells which live in pond and lake water. The cell's color is due to chlorophyll, and each spirogyra cell has a tough cell wall. Would you call it a plant or animal?

Another common one-celled bit of life is *euglena*. It is shaped like a pear and does not have a tough cell wall. But inside its thin outer membrane are green bits of chlorophyll—so the cell can make its own food. (Actually there are a few types of euglena that lack chlorophyll and cannot make their own food.) Euglena moves about in the water by pulling itself along with a whiplike "tail." It also has a red spot that is sensitive to light. This spot helps euglena to find just the right kind of light for its food-making action. During darkness, euglena keeps alive by taking in food through its cell membrane. Is euglena a plant or animal?

Euglena has puzzled scientists for many years. In some ways it is a plant, but in other ways it is an animal. It is like an animal because it has a light-sensitive spot and because it has a thin membrane. But it is like a plant because it has green chlorophyll and makes its own food most of the time. Some scientists call euglena a plant, others say it is an animal. A few scientists say it is neither and call it a "plantimal."

There are many part-plant, part-animal organisms like euglena. One that lives in fresh-water ponds is *volvox*. It is a round group of single cells that have light-sensitive spots and cell membranes (like animals), and green chlorophyll (like plants).

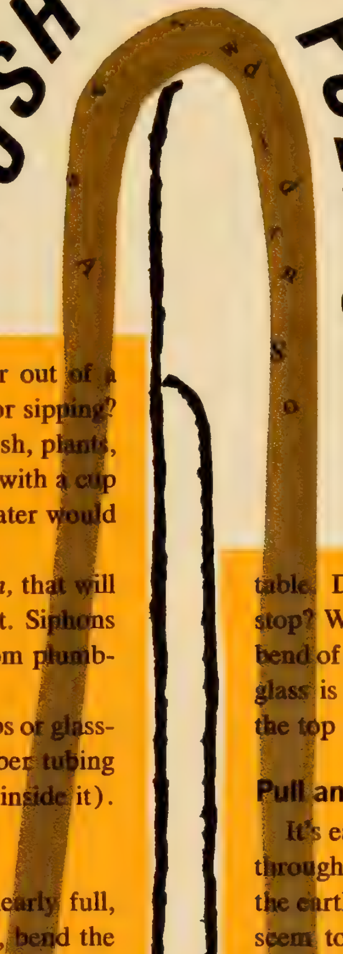
Euglena, volvox, and other "plantimals" make some scientists think that there should be three Kingdoms: Plant, Animal, and *Protista*. The Protista Kingdom would include all forms of simple life, such as euglena, volvox, and ameba. The reason for choosing the word "protista" is that "pro" means "first" in Greek. These tiny cells are probably like the earliest forms of life on earth, and from them plants and animals may have developed.

Scientists are not surprised that euglena and other "plantimals" do not fit neatly into either the Plant or Animal Kingdoms. After all, these kingdoms are a grouping made by man, not by nature. Ever since man first began to study the world around him, he has tried to make rules that help explain what he sees. Some of these rules work well; others not so well. As new discoveries are made, the rules are made more accurate.

The grouping of all life into the Plant or Animal Kingdoms worked very well until the microscope revealed the world of tiny "plantimals." Now it seems that a new grouping of Plant, Animal, and Protista Kingdoms gives a better picture of life as it is ■

THE PUSH AND PULL of siphons

With a piece of bent tubing, you can find out how a siphon works, then use your findings to solve the siphon puzzles on the next two pages.



■ Can you think of a way to take water out of a dirty aquarium without tipping, dipping, or sipping? Tipping the aquarium would disturb the fish, plants, and sand or gravel. Dipping the water out with a cup would take a lot of work. Sipping dirty water would be dangerous.

There's a simple device, called a *siphon,* that will do this job with little effort on your part. Siphons are used in many ways, including bathroom plumbing *(see page 16).*

All you need to make a siphon is two cups or glasses and a 12-inch length of plastic or rubber tubing (clear plastic is best because you can see inside it).

Making Your Siphon

Pour water into one glass until it is nearly full, and place the empty glass beside it. Next, bend the tubing into a "U" shape and fill it with water from a faucet. (With clear plastic tubing, you can make sure that there are no air bubbles inside the tube.) When the tube is full of water, seal the opening at each end with a finger, turn the "U" upside down, and hold one end under water inside the filled glass and the other end inside the empty glass. Now, take your fingers away from both ends of the tube.

What happens? (If only a little bit of water drops into the empty glass, there may have been some air bubbles inside the tube. Carefully fill it with water and try again until the water flows steadily from the filled glass to the empty one.) Once the water is flowing, when does it stop? Does the flow slow down before it stops?

Now place an empty glass on a stack of two or three saucers and a filled glass on the table beside it. Can you make the siphon work? Try placing the filled glass on the saucers and the empty one on the table. Does the siphon work now? When does it stop? Will the siphon work if the distance from the bend of the siphon to the top of the water in the filled glass is farther than the distance from the bend to the top of the water in the other glass?

Pull and Push

It's easy to guess what makes the water flow down through the siphon into the empty glass—the pull of the earth's gravity. But what makes this falling water seem to pull water up through the tube from the filled glass? You may have guessed that the weight of the earth's atmosphere pressing down on the water in the filled glass is what pushes water up into the tube. As the water falls out of one side of the tube, the water in the other side is pushed through the tube to fill the space left by the falling water. Can you guess now why a bubble of air in the tube keeps the siphon from working?

The earth's atmosphere pushes equally hard on the top of the water in both glasses. Can you figure out why the water flows more slowly as the water in the two glasses nears the same level?

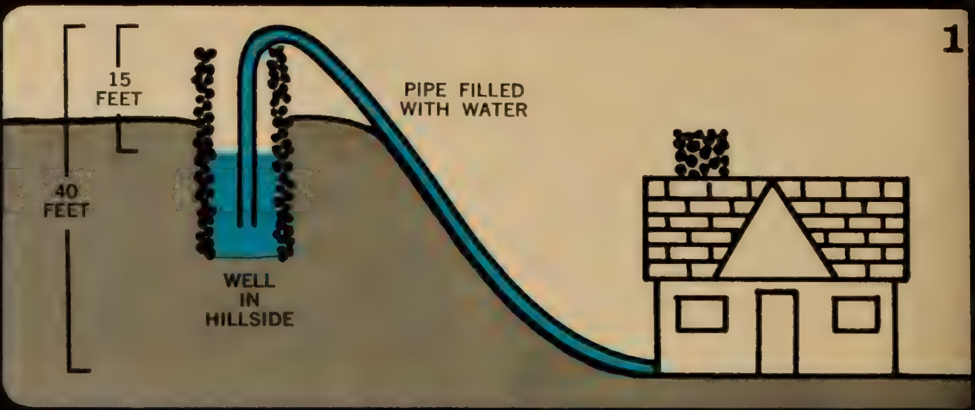
The earth's atmosphere can push water through a siphon if the top of the siphon is no more than about 25 feet above the top of the water supply. With this information and what you find out from your investigations, see if you can figure out whether the siphons shown on the next two pages would work, and if so, what would happen ■

WHICH OF THESE SIPHONS WOULD WORK?

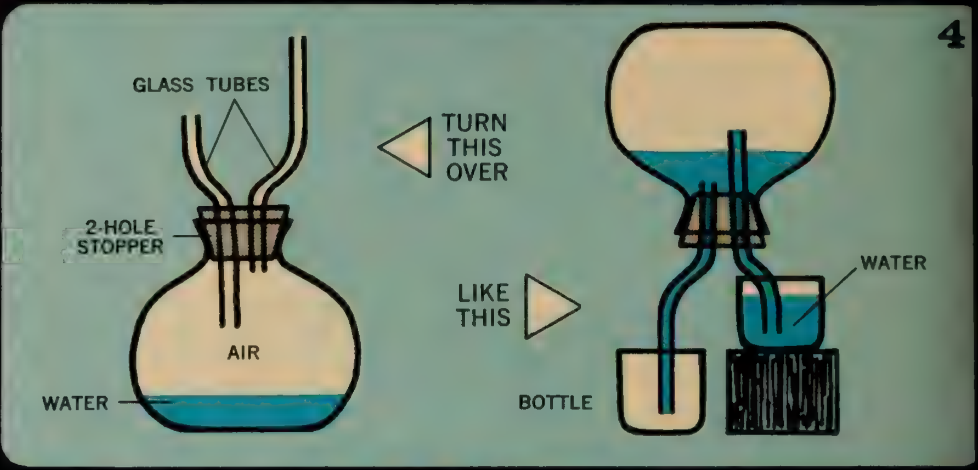
Each of these diagrams shows an attempt to use a siphon to do a particular job. In each case except Diagram 4, the tubes have been filled with liquid—water, salt water, sugar water, or mercury. Can you figure out which of these siphons would work, and if so, what would happen? How many other ways can you think of to use a siphon?

—JAMES E. FRAZER

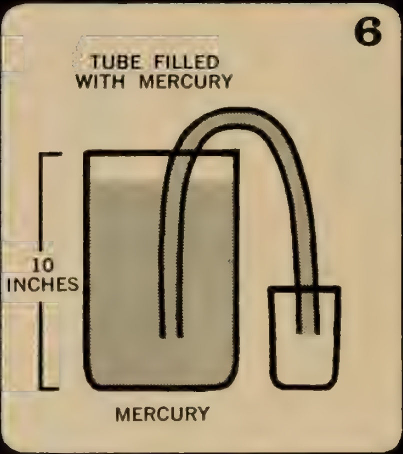
1


15 FEET
40 FEET
PIPE FILLED WITH WATER
WELL IN HILLSIDE

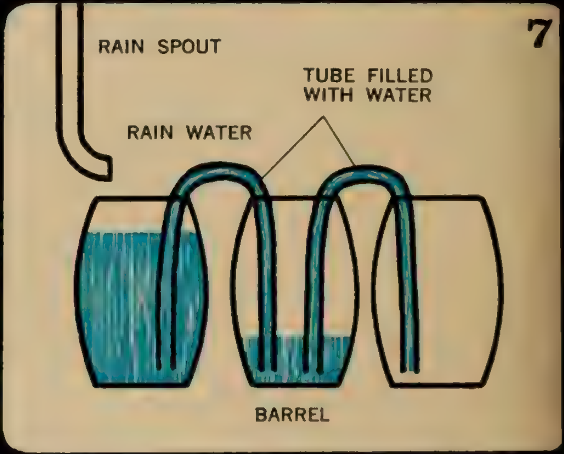
4


GLASS TUBES
2-HOLE STOPPER
AIR
WATER
TURN THIS OVER
LIKE THIS
WATER
BOTTLE

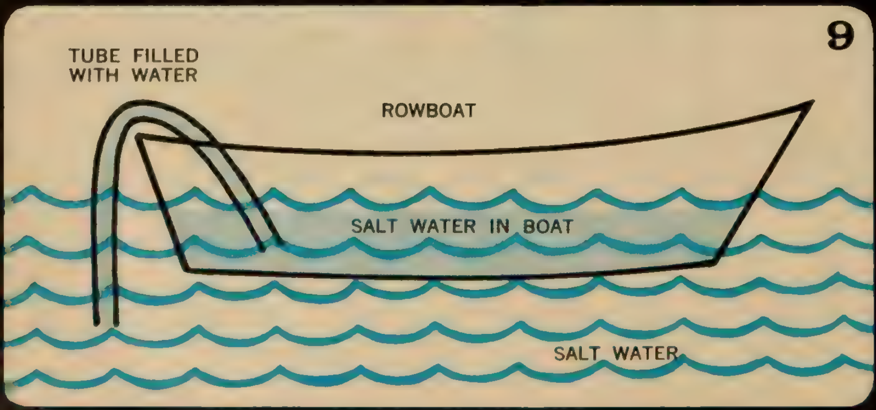
6


TUBE FILLED WITH MERCURY
10 INCHES
MERCURY

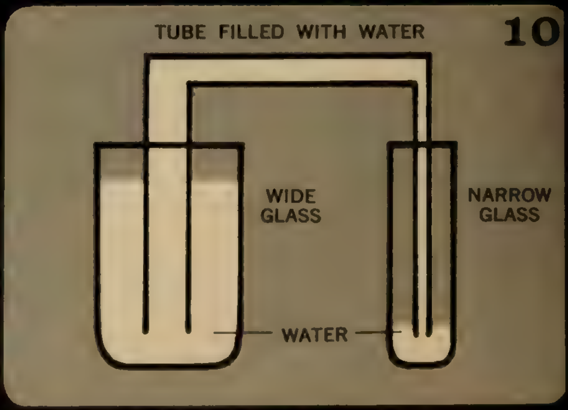
7


RAIN SPOUT
TUBE FILLED WITH WATER
RAIN WATER
BARREL

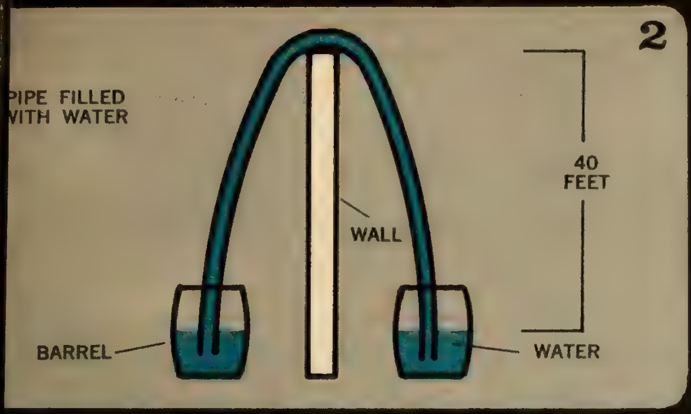
9


TUBE FILLED WITH WATER
ROWBOAT
SALT WATER IN BOAT
SALT WATER

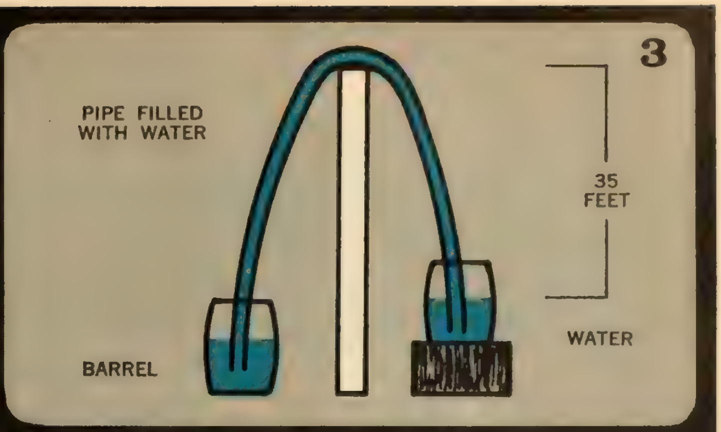
10


TUBE FILLED WITH WATER
WIDE GLASS
NARROW GLASS
WATER

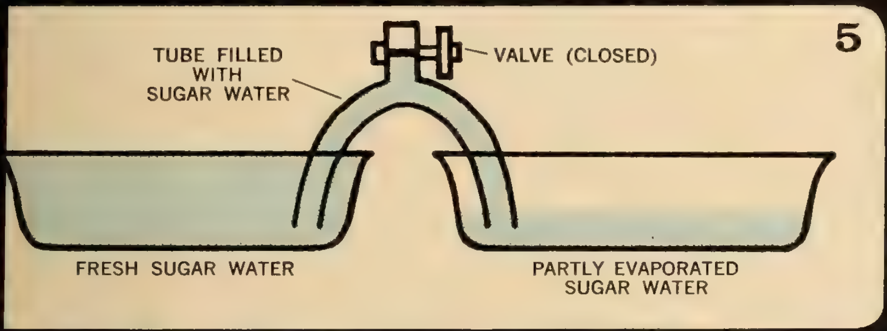
2


PIPE FILLED
WITH WATER
WALL
40 FEET
BARREL
WATER

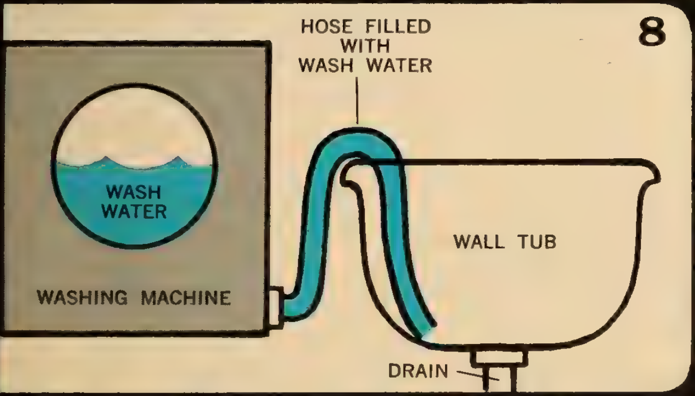
3


PIPE FILLED
WITH WATER
35 FEET
WATER
BARREL

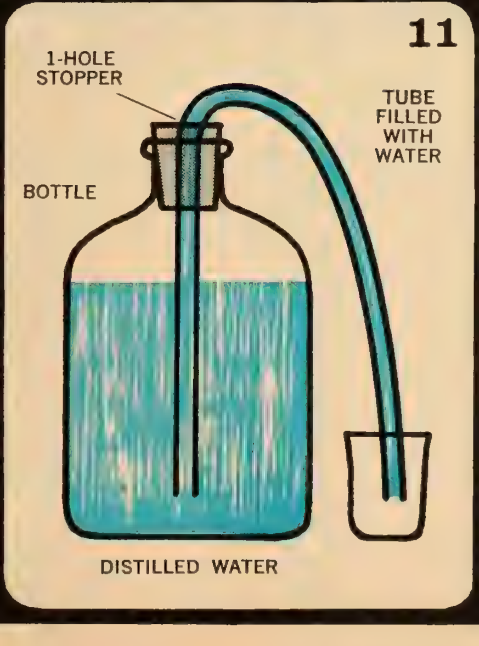
5


TUBE FILLED WITH SUGAR WATER
VALVE (CLOSED)
FRESH SUGAR WATER
PARTLY EVAPORATED SUGAR WATER

8


HOSE FILLED WITH WASH WATER
WASH WATER
WASHING MACHINE
WALL TUB
DRAIN

11


1-HOLE STOPPER
BOTTLE
TUBE FILLED WITH WATER
DISTILLED WATER

ANSWERS TO SIPHON PUZZLES

1. The water would flow out of the well and into the cabin.

2. The water would drop down about 15 feet in each side of the tube, leaving the top of the tube almost empty. (If the tube were not rigid, the pressure of the atmosphere would make it collapse.)

3. The water would drop down in each tube to about 25 feet above the water in the barrels.

4. This is a self-starting siphon. The water in the bottle would start running out into the lower glass. This would let the air in the bottle spread out so that it was not pushing downward as hard as the atmosphere was pushing down on the top of the water in the filled glass. The water in the filled glass would be pushed up into the bottle, making a tiny fountain, which would run as long as there was water in the upper glass.

5. Fresh sugar water would flow until it reached the same level in both pans.

6. Mercury is heavier than water, but it would fill and overflow the small container.

7. The water would run from one barrel into the next until it reached the same level in all three barrels.

8. All of the wash water would flow down the drain.

9. The water would flow **into** the boat until it reached the same level as the water around the boat.

10. The water would reach the same level in both glasses.

11. Only a little water would run into the small glass. The atmosphere would be pressing on the glass bottle instead of on the top of the water in it.

HOW IT WORKS

Toilets

■ One of the most common uses of the *siphon (see page 13)* is to remove waste materials from a toilet, or water closet, through a drain pipe and into a sewer.

The bowl of a toilet is shaped something like a large funnel with a "spout" that is bent upward in a U-shape. The spout is hidden behind the back of the bowl, and it is connected to the drain pipe *(see Diagram 1A)*. Most of the time the bowl and spout are partly filled with water. (The water in the spout seals it off so that no unpleasant odors can come into your bathroom through the drain pipe.)

When you flush the toilet, from four to six gallons of water flow from the tank through the rim of the bowl and down into the bowl. This water piles up in the bowl and pushes some of the water in the spout over the edge of the spout into the drain pipe *(see Diagram 1B)*. The spout and drain pipe form a siphon, and water flowing through it carries off waste materials from the bowl into the drain pipe. The siphon action continues until the bowl is empty. Then some of the clear water that is left in the spout flows back into the bowl.

In most toilet systems, the main drain pipe, or *stack*, sticks up through the roof of the building and is open. Unpleasant odors escape through it, and the air pressing in from the stack stops the siphon action when the bowl is empty, so that some water is left in the spout.

How the Tank Refills

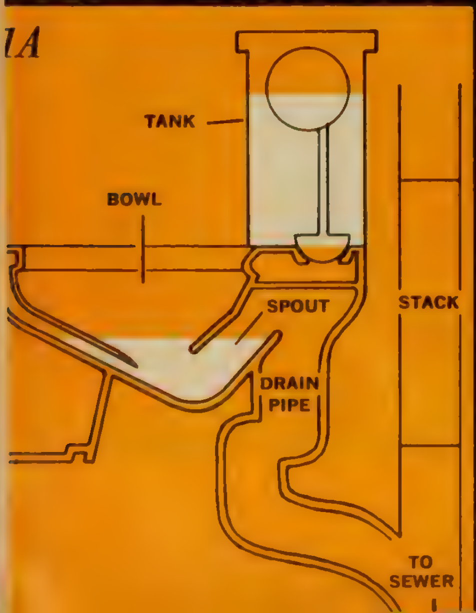
After the toilet is flushed, water flows into the tank until it reaches the proper level. If you lift the top off of the tank you can see how this works and what keeps the water from overflowing.

Push the lever to flush the toilet. The other end of the lever lifts a rod that pulls a rubber ball (or something similar) out of the hole in the bottom of the tank *(see Diagram 2A)*. Opening this *exhaust valve* lets water flow to the bowl. As the level of the water drops in the tank, a hollow ball, called the *float*, moves down with the water. The float is connected to the *intake valve* by a rod that works like the handle on a faucet. When the tank is nearly empty, the rubber ball drops into the hole, closing the exhaust valve. And when the float nears the bottom of the tank, its rod opens the intake valve, letting water flow into the tank from a water pipe *(see Diagram 2B)*.

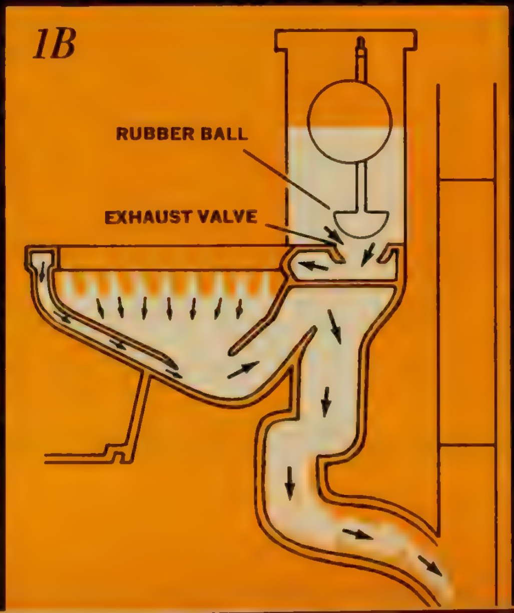
Sometimes the rubber ball fails to drop into the hole. When this happens, water flowing into the tank keeps running into the bowl. You can stop this waste of water by pushing the ball down into the exhaust hole.

As the tank fills up, the float rises, lifting the rod until the water reaches the proper level in the tank and the intake valve is closed. In this way, the amount of water left in the tank controls the intake of water into the tank This is called *control by feedback*, because the float "feeds back" information about the level of the water in the tank to the intake valve. Control by feedback is used in many kinds of machines, chemical processes, and electronic devices. A thermostat works by feedback. So does an automatic tire pump. Can you think of some other things that are controlled by feedback? (How about hunger?) ■

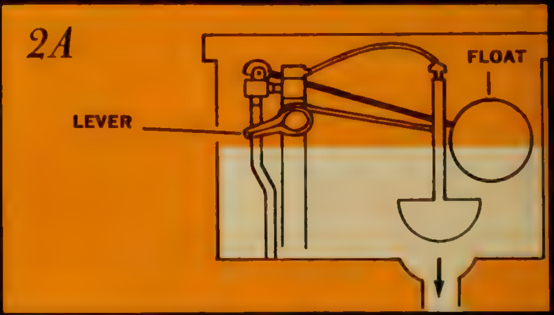
1A



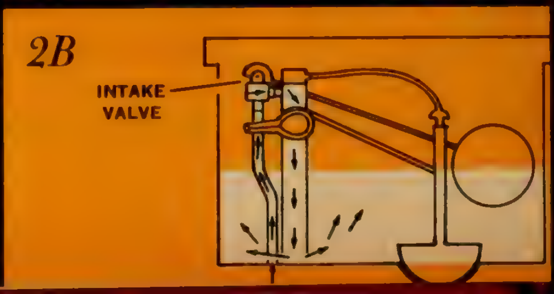
1B



2A



2B



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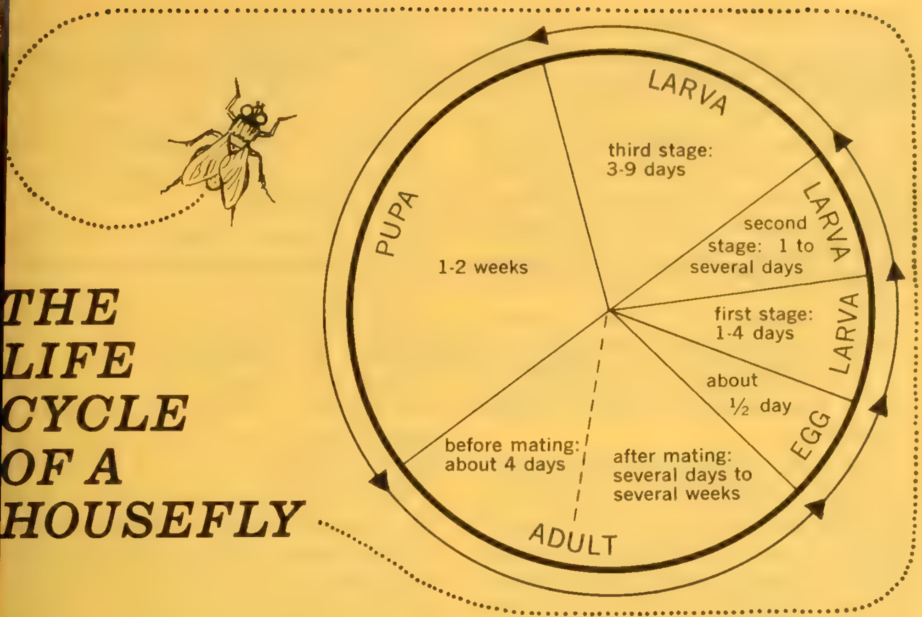
THE LIFE CYCLE OF A HOUSEFLY


LARVA
third stage: 3-9 days
LARVA
second stage: 1 to several days
LARVA
first stage: 1-4 days
EGG
about ½ day
after mating: several days to several weeks
ADULT
before mating: about 4 days
PUPA
1-2 weeks

Using This Issue . . .
(continued from page 2T)

arctic regions and some places of high altitude, the fly lives wherever man lives. Were it not for the food, protection, and breeding places that human habitation provides, flies could not exist in such abundance. In cities, where there is no manure and where sewage is usually adequately managed from this viewpoint, the weakest link in fly control is likely to be improper garbage disposal.

- *How fast do houseflies reproduce?* The shortest possible generation time is about three weeks *(see diagram).*

A scientist has estimated that if all the offspring of a pair of flies were to live and reproduce, one pair of flies could have several trillion descendants in one summer! Barriers to this fecundity include lack of a suitable place for egg laying, drying up of the larval habitat, and predation.

—Nancy Kent Ziebur

PAGE 8 A Look at Eyes

The central idea of this Wall Chart is *adaptation.* Over millions of years, the eyes of each different kind of animal have evolved so that the animal can survive in its environment. The compound eyes of insects, for example, may not give as sharp an image as human eyes, but they suit the insect's needs.

You can make the point nicely by using the examples given in the chart. Compare the swift-flying, predatory dragonfly, with 28,000 parts in each compound eye, with a subterranean ant, whose eye has only six or eight parts. Ask your pupils to think of the habits of a housefly and then guess the number of small eyes in its compound eyes. These insects, fairly fast fliers, have about 14,000 parts in each compound eye.

The chart provides a good opportunity to introduce the study of the human eye and its parts. Whenever possible, compare parts of the human eye with the same or similar parts of other animals' eyes; then relate them to the requirements of the animals' environment.

For example, the human retina is rich in sensitive cells called *cones,* which give sharp, colorful images in bright light. Humans have relatively few *rods,* which give indistinct, noncolored images in dim light. In a nocturnal animal, the relative number of rods and cones is usually reversed. However, most animals with rod-rich eyes (such as owls and dogs) have sharp senses of hearing or smell which supplement their somewhat indistinct vision.

Topic for Class Discussion

- *Photographs have been taken through insect eyes. Do such pictures show what an insect sees?* The images that come through each part of an insect's eye are sent to the animal's brain, where sight occurs. Scientists can only make educated guesses at what other animals see.

How Does a Fly Say "No"?
(continued from page 1T)

that makes getting direct answers to questions difficult. With a human subject it is only necessary to ask: What color is this? Does that hurt? Are you hungry? The human subject may, of course, lie; the fly cannot. However, to elicit information from him it is necessary to resort to all kinds of trickery and legerdemain. This means pitting one's brain against that of the fly—a risk some people are unwilling to assume. But then, experimentation is only for the adventuresome, for the dreamers, for the brave.

It is risky even at higher levels. I am reminded of the eminent professor who had designed experiments to test an ape's capacity to use tools. A banana was hung from a string just out of reach. An assortment of tools, that is, boxes to pile up, bamboo poles to fit together, etc., were provided, and the ape's ability was to be judged by his choice of method. To the chagrin of the professor, the ape chose a method that had never even occurred to that learned gentleman.

Extracting information from a fly can be equally challenging. Take the question of taste, for example. Does a fly possess a sense of taste? Is it similar to ours? How sensitive is it? What does he prefer?

Watch a Fly Eat Dinner

The first fruitful experimental approach to this problem began less than 50 years ago with a very shrewd observation; namely, that flies (and bees and butterflies) walked about in their food and constantly stuck out their tongues. The next time you dine with a fly (and modern sanitary practice has not greatly diminished the opportunities), observe his behavior when he gavots across the top of the custard pie. His proboscis, which is normally carried retracted into his head like the landing gear of an airplane, will be lowered, and like a miniature vacuum cleaner he will suck in food. For a striking demonstration of this, mix some sugared water and food coloring and paint a sheet of paper. The first fly to find it will leave a beautiful trail of lip prints, hardly the kind suitable for lipstick ads, but nonetheless instructive.

Proboscis extension has been seen thousands of times by thousands of people but few have been either struck

(Continued on page 8T)

How Does a Fly Say "No"?

(continued from page 7T)

by the sanitary aspects of the act or ingenious enough to figure out how they might put the observation to use to learn about fly behavior.

The brilliant idea conceived by the biologist who first speculated on why some insects paraded around in their food was that they tasted with their feet. In retrospect it is the simplest thing in the world to test this idea. It also makes a fine parlor trick for even the most blasé gathering.

A Handle for a Fly

The first step is to provide a fly with a handle since nature failed to do so. Procure a stick about the size of a lead pencil. (A lead pencil will do nicely. So will an applicator stick, the kind that a physician employs when swabbing a throat.) Dip one end repeatedly into candle wax or paraffin until a fly-sized gob accumulates. Next anesthetize a fly. The least messy method is to deposit him in the freezing compartment of a refrigerator for several minutes. Then, working very rapidly, place him backside down on the wax and seal his wings onto it with a hot needle.

Now for the experimental proof. Lower the fly gently over a saucer of water until his feet just touch. Chances are he is thirsty. If so, he will lower his proboscis as soon as his feet touch and will suck avidly. When thirst has been allayed, the proboscis will be retracted compactly into the head. This is a neat arrangement because a permanently extended proboscis might flop about uncomfortably during flight or be trod upon while walking.

Next, lower the fly into a saucer of sugared water. In a fraction of a second the proboscis is flicked out again. Put him back into water (this is the control), and the proboscis is retracted. Water, in; sugar, out. The performance continues almost indefinitely. Who can doubt that the fly can taste with his feet? The beauty of this proboscis response, as it is called, is that it is a reflex action, almost as automatic as a knee jerk. By taking advantage of its automatism, one can learn very subtle things about a fly's sense of taste.

Test Your Taste Against a Fly's

For example, who has the more acute sense of taste, you or the fly? As the cookbooks say, take 10 saucers. Fill the first with water and stir in one teaspoon of sugar. Now pour half the contents of the saucer into another which should then be filled with water. After stirring, pour half of the contents of the second saucer into a third and fill it with water. Repeat this process until you have a row of 10 saucers. Now take a fly (having made certain that he is not thirsty) and lower him gently into the most dilute mixture. Then try him in the next and so on up the series until his proboscis is lowered. This is the weakest sugar solution that he can taste.

Now test yourself. If you are the sort of person who does not mind kissing his dog, you can use the same saucers as the fly. Otherwise make up a fresh series. You will be surprised, perhaps chagrined, to discover that the fly is unbelievably more sensitive than you. In fact, a starving fly is 10 million times more sensitive.

You console yourself with the thought that he may be less versatile, less of a gourmet, than you. Well, this too can be tested. Try him on other sugars; there are any number of sugars: cane sugar, beet sugar, malt sugar, milk sugar, grape sugar. Each is chemically different; each has for you a different sweetness. It is only necessary to determine for each the most dilute solution that will cause the fly to lower his proboscis. Then when the sugars are listed in order of decreasing effectiveness, it turns out that the order is the same for you and the fly: grape sugar, cane sugar, malt sugar, milk sugar, beet sugar. In one respect the fly is less gullible; he is not fooled by saccharine or any other artificial sweeteners.

> i scurry around
> gutters and sewers
> and garbage cans
> said the fly and
> gather up the germs of
> typhoid influenza
> and pneumonia on my
> feet and wings . . .
>
> then i carry the germs
> into the households of
> men
>
> ……
>
> . . . it is my mission
> to help rid the world
> of these wicked persons
> i am a vessel of righteousness
> scattering seeds of justice
> and serving the noblest uses

—*from* the lives and times of archy and mehitable, *by Don Marquis. Copyright 1927, 1930, 1933, 1935 by Doubleday & Company, Inc.*

But, you may argue, I can distinguish many other kinds of tastes. This is partly correct. You can distinguish many kinds of flavors, but to assist you in this you recruit your nose. Flavor is a mixture of tastes, odors, and textures. With taste alone you are pretty much restricted to sweet, salt, sour, and bitter.

The old adage that one can catch more flies with honey than with vinegar has a sound basis in physiology. Leaving aside for the moment the fact that flies react differently to different odors, the truth remains that flies accept materials that taste sweet to us and reject those that taste salt, sour, or bitter to us. This fact, too, can be demonstrated with the proboscis response, but the only way for a fly to say "No" is to retract his proboscis, and it can be retracted only if it is first extended. Accordingly, one prepares several saucers of sugared water. A pinch of salt is added to one, two pinches to another, three pinches to a third, and so on. As before, the fly is lowered gently into the saucer with the least salt. He responds, as expected, by extending his proboscis. He is then allowed to taste the next dish, and the next, and the next. At one of these dishes he will stubbornly refuse to extend his proboscis. Since this dish contains the same amount of sugar as the rest, one must conclude that it is the salt that is being rejected. The test can be repeated with vinegar, lemon juice, quinine water, aspirin, bicarbonate of soda—anything that will dissolve in water.

"Coating a Pill"

If you wish to be really sophisticated, you can test the relative sensitivity of his legs and mouth by standing him in one solution and allowing his proboscis to come down into a different one. A friend of mine who once wished to study the stomach of the fly and to color it so it could be seen more easily under the microscope hit upon the idea of standing a fly in sugar but arranging for its mouth to come down in dye. As a result the fly's insides were stained beautifully. This is one example of a physiological way to coat a pill ■

nature and science
TEACHER'S EDITION

VOL. 3 NO. 3 / OCTOBER 18, 1965 / SECTION 1 OF TWO SECTIONS

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How Fossils Are Used

by William H. Matthews III

■ Fossils are useful in a number of ways. Prehistoric man utilized fossils in an attempt to ward off evil spirits. The medicine men of certain primitive cultures of today use fossils in the belief that they possess some mysterious power of healing. The scientist, however, uses these ancient remains in order to recreate the geologic history of the earth. Fossils are also of practical use in a number of modern industries.

Perhaps the chief importance of fossils is in the tracing of the development of plants and animals. The fossils in the older rocks are primitive and relatively simple, but similar specimens that lived in later geologic time are more complex and more advanced. Every fossil provides some information about when it lived, where it lived, and how it lived.

Dating Layers of Rock

Fossils can provide important clues to the age of the rocks containing them, because there is a definite relation between the fossil content of the rocks and the position of these rocks in the geologic column.

We know that in a normal sequence of sedimentary rocks younger strata are laid down on top of older strata. Hence it follows that older fossils will normally be found at the bottom of the geologic column, with younger fossils near the top of the column.

In some areas, however, the rocks have been disturbed by crustal deformation. In these regions the beds may have been overturned or older rocks thrust on top of younger ones. If the strata in the area are fossiliferous and if the geologist knows the order in which the fossils normally occur in the section, he can then work out the proper stratigraphic sequence. This is possible because of the *law of faunal and floral succession*, which states that assemblages of fossil plants (*floras*) and animals (*faunas*) succeed one another in a definite and determinable order. The floras and faunas are distinctive for each portion of earth history, and a comparison of these fossil assemblages often enables the geologist to recognize deposits of the same age. This is frequently possible even when the deposits are in widely separated areas.

The use of fossils to demonstrate the relationships of certain rock units is called *biologic*, or *paleontologic*, *correlation*. This is the most valuable and common use that is made of fossils.

Clues to Climates of the Past

Fossils have been successfully used to demonstrate the existence of different climatic conditions in the geologic past. If we find the remains of tropical plants or animals in a region that has a temperate or cold climate today, we may assume that a tropical climate prevailed in that area at one time. For example, the fossil ferns found in Antarctica and the fossil magnolias reported from Greenland indicate a much warmer climate for these areas in other times.

Coal deposits commonly contain the remains of ferns and other plants which suggest warm, swampy conditions; yet many of these coal deposits are found in parts of the world that are much too cold and/or dry to support this type of vegetation today.

Glacial, or colder, climates may be

(Continued on page 7T)

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nature and science
EXPLORING PREHISTORIC LIFE
The Duck-Billed Dinosaur Puzzle see page 10

IN THIS ISSUE

Announcing
nature and science
CLASSROOM WALL CHARTS
(see page 3T)

(For classroom use of articles preceded by ●, see pages 2T and 7T.)

● Death Trap of Old Los Angeles
This story of a famous fossil find tells your pupils how scientists reconstruct extinct animals from their remains and figure out how the animals probably lived.

Back Yard Mastodon
Three teeth found by two boys led to a much larger fossil find.

● Exploring for Fossils
Your pupils can search for fossils, recover them intact, and build a collection with scientific value.

Fossils You May Find
This Wall Chart will help your pupils identify common types of animal and plant fossils.

● The Duck-Billed Dinosaur Puzzle
The duck-bills lived in the water. Or did they? A paleontologist who disagrees explains his case.

● The Tell-Tale Dust
Scientists use plant pollen to find out how climate and vegetation have changed over thousands of years.

IN THE NEXT ISSUE

Science Workshops in heat and cold, color and color perception, how a cantilever works . . . Science Mystery: How do the green turtles navigate? . . . How animals and plants survive in winter.

USING THIS ISSUE OF NATURE AND SCIENCE IN YOUR CLASSROOM

Most children are fascinated by fossils, whether they are the skeletons of huge dinosaurs or impressions left in rock by tiny invertebrate animals. The articles in this special-topic issue will help your pupils to understand the importance of fossils as records of the slow but continuous change that is a basic process in nature—change in the structure and function of living things, in the structure of the earth's crust, and in the climate of different areas.

The article beginning on page 1T gives you additional information about "How Fossils Are Used." Questions based on it can lead to valuable class discussion.

2 Death Trap

You might point out to your pupils that tar pits are not very common, and neither are complete skeletons of extinct animals. The La Brea find, with bones intact and well preserved in tar, gave scientists unusually good material on which to base reconstructions of the animals.

To answer the questions asked under the heading "Why Is It So?" on page 3—

- Plant-eating animals usually outnumber meat-eating animals because so many plant-eaters are required to produce food for each meat-eater (*see "food pyramid" diagram*).
- In the La Brea pit, fossils of meat-eaters outnumber those of plant-eaters because meat-eaters were lured to the pit by the odor of dead animals and were trapped when they tried to feed on them.

6 Exploring

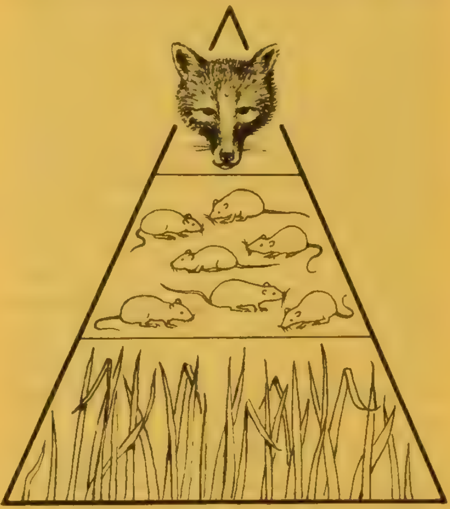
The word fossil comes from the Latin word *fossilis*, meaning "dug up." For years any object dug up from the ground was called a "fossil," even such items as minerals. But today we think of fossils as the signs of animals and plants found buried in the earth that are at least 10,000 years old.

Suggestions for Classroom Use

If any of your pupils have fossils, have them show them to the class and try to identify what kind of animal or plant they came from. (The chart on pages 8 and 9 will help to identify remains of animals without backbones and some plants. Books listed at the end of the article will be helpful in identifying other types.)

You might ask one of your pupils to look in some of those books and report to the class on the different ways that fossils are formed. Or have several pupils discuss the subject in a panel session before the class.

Briefly, hard parts such as teeth, bone, and shells are often preserved intact. Sometimes bones have been dissolved and replaced by mineral matter in the shape of the bones. Also, the shape of an animal or plant that was pressed between layers of clay may be preserved as a mold in the hardened clay even though the animal or plant has been dissolved out of it.



A "food pyramid" shows the quantitative relationships of food chains. As energy from the sun moves through green plants and on up the pyramid, each organism uses some of the energy and gives off some in the form of work and heat. Therefore, there is less energy available for the group of organisms above. A particular area may provide energy for many thousands of plants, hundreds of mice, and perhaps only one fox.

Soft marine animals or plant leaves that were pressed between layers of clay which are now shale sometimes leave a thin layer of carbon that reveals their outline and some of their internal structure.

In petrified wood, most of the organic material has been dissolved and replaced by various minerals.

The footprints or trails of animals in mud are sometimes preserved as the mud hardens into rock. (The "Mystery Photo" in Brain-Boosters, page 16, shows tracks of earthworms in mud.)

Holes bored by worms or molluscs are sometimes preserved in petrified wood, rock, or the shells of other molluscs. Even animal droppings that have hardened over the ages are useful fossils; they reveal what the animals ate.

10 Dinosaur Puzzle

Paleontology is not as exact a science as, say, chemistry or biology, because so many of its conclusions must be reached by inference and can not be proved by observation or experiment. Dr. Ostrom's article shows how acceptance of an idea on the basis of inadequate evidence may lead scientists to make unreasonable interpretations of new evidence.

Topics for Class Discussion

- *How did scientists come to think that the duck-billed dinosaurs had lived in lakes and swamps?* Dr. Leidy's report on the first duck-bill fossil find suggested that they were "probably amphibious," but gave no reason for this idea. Edward Cope mistakenly decided that the duck-bills' teeth could only chew soft, water plants. Later scientists assumed this meant that the duck-bills lived in the water.
- *Why was this idea accepted as correct for about 100 years?* Since later scientists were already convinced that the duck-bills were water animals,

(Continued on page 7T)

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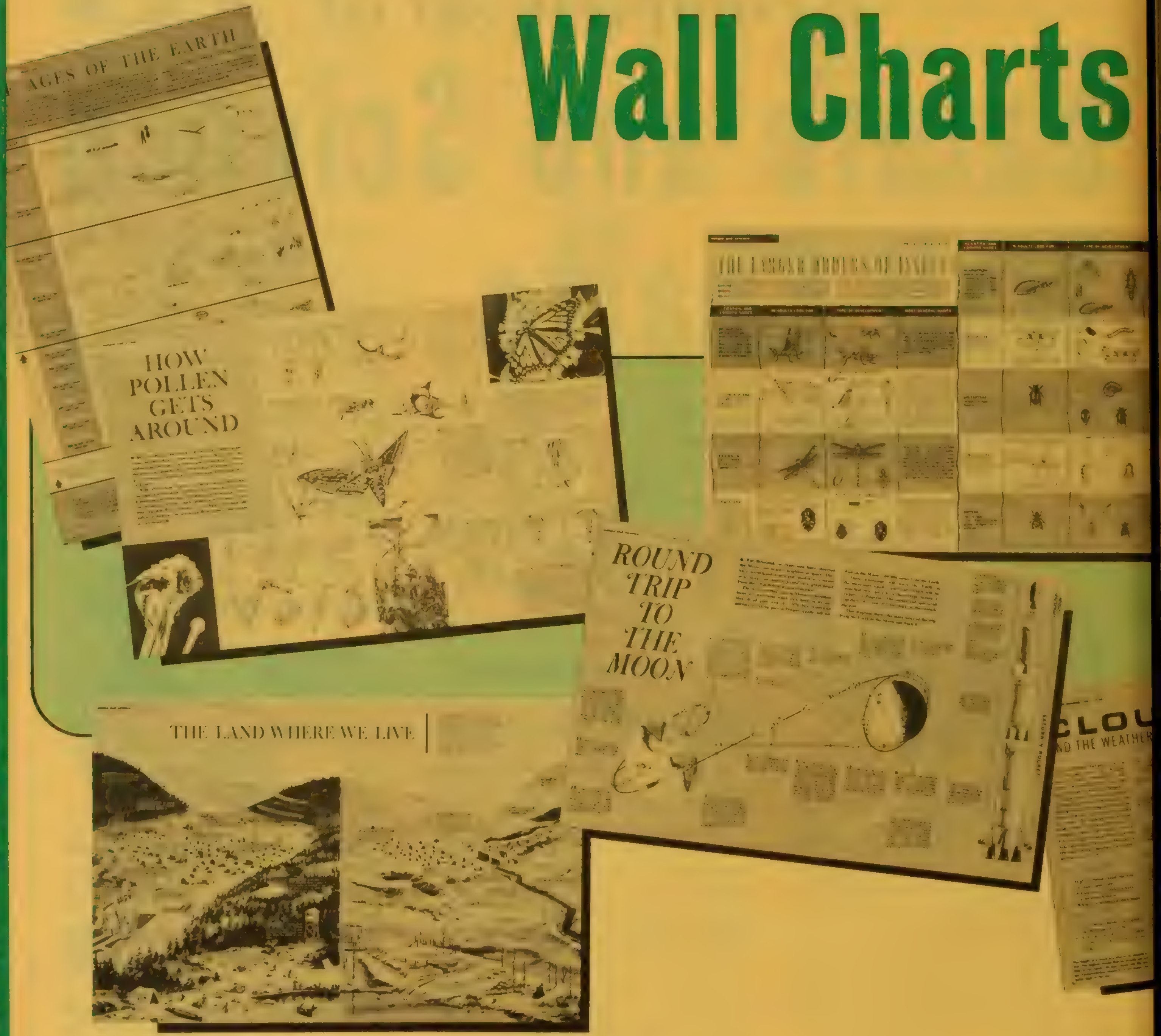
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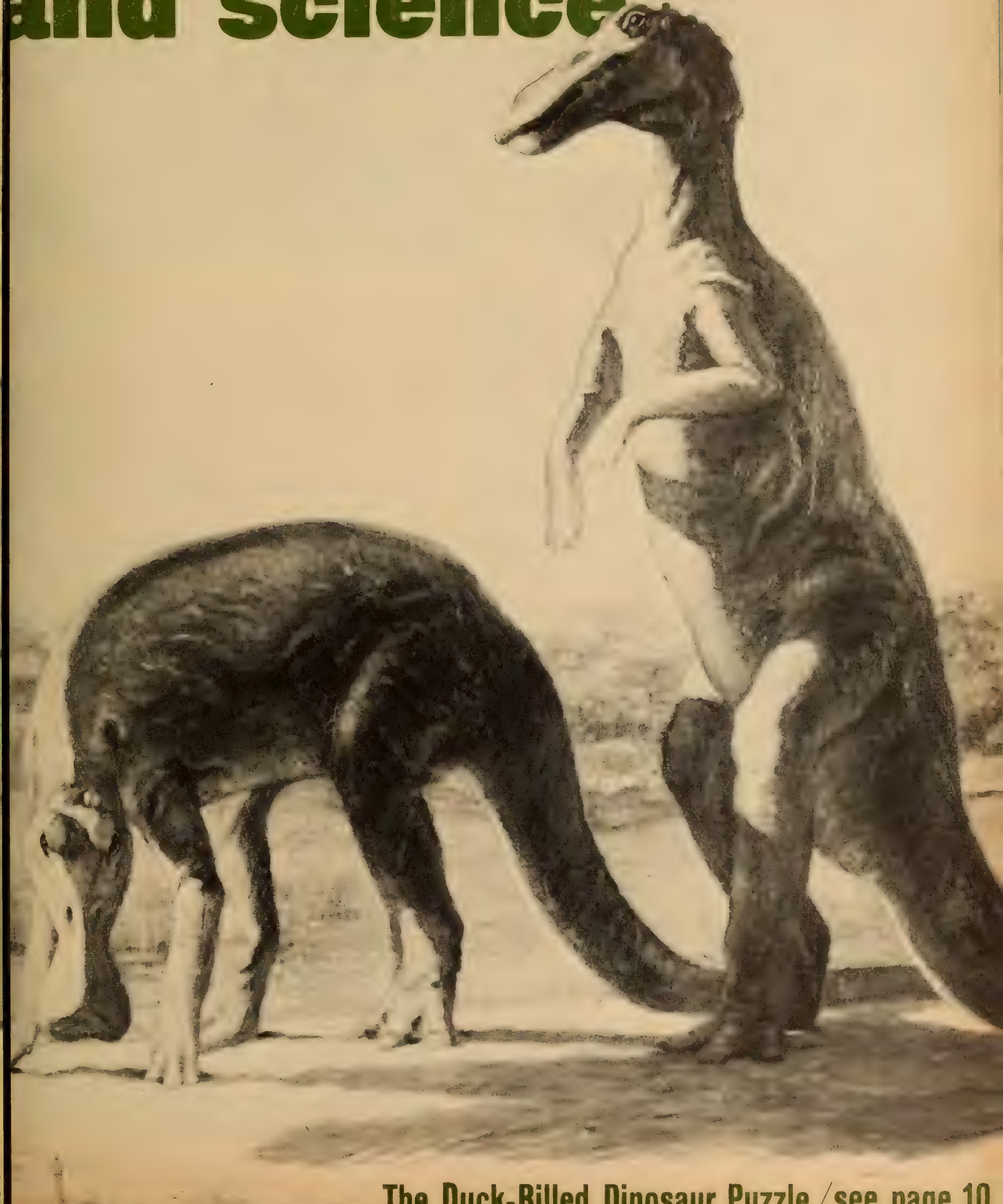

The Duck-Billed Dinosaur Puzzle / see page 10

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DEATH TRAP OF OLD LOS ANGELES

by Dan Welch

Giant sloths, mammoths, and saber-tooth cats came to these quiet pools for food and water. Instead they sank into tar, leaving bones and teeth as clues to the past.

■ A huge ground sloth lumbered toward the pool of dark water. He was as big as a rhinoceros, and slow-witted. Had he been more alert, he might have noticed a saber-tooth cat lurking in weeds at the pool's edge.

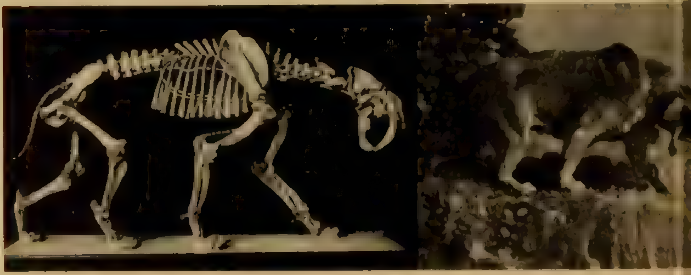
The sloth was thirsty. He did not notice the foul smell of decay as he neared the pool. The bones sticking out of the shallow water meant nothing to him. But as the sloth moved farther out into the pool, he started sinking into the soft bottom. His body thrashed and heaved frantically, but he only sank deeper.

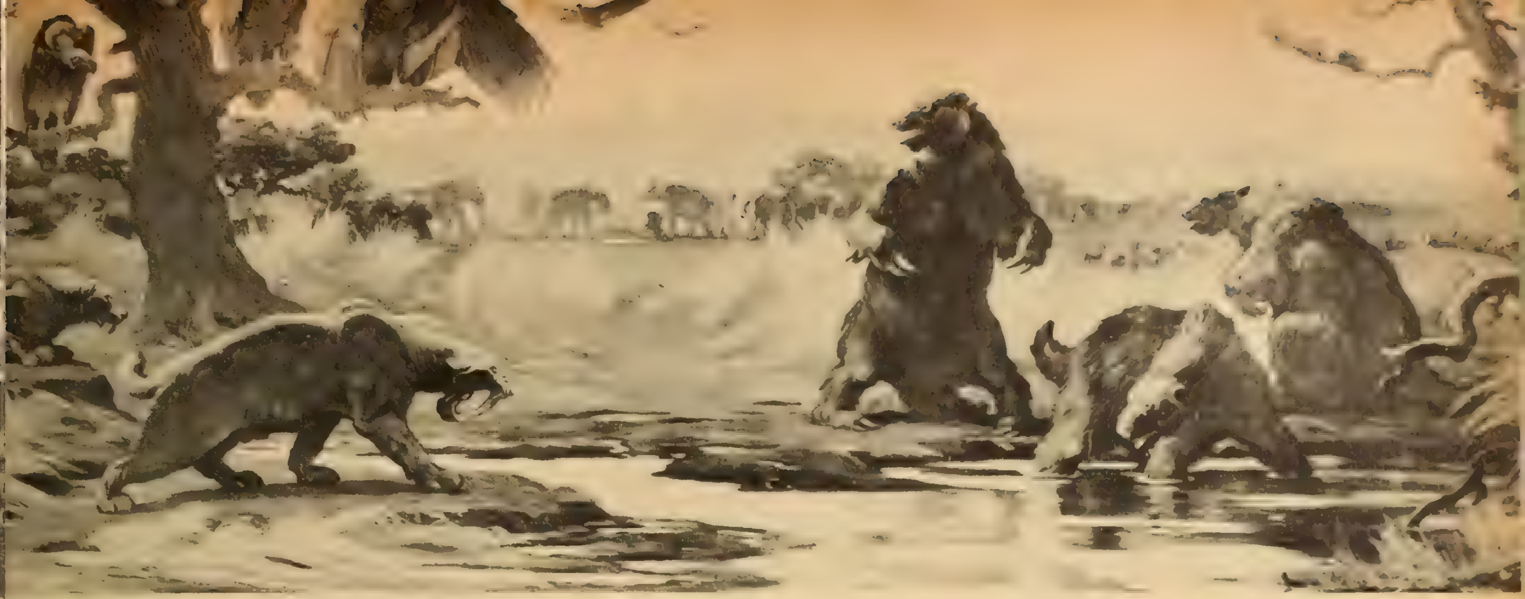
Even as the sloth tried to escape the pool's tarry bottom, a saber-tooth cat attacked him, slashing into the sloth's flesh with its eight-inch-long teeth. Other saber-tooths and wolves gathered on shore, then joined in the attack. They, like the sloth, were caught in the tar. In a few hours, their bodies disappeared in the inky ooze.

Fossil Clues from a Death Trap

Giant sloths, saber-tooth cats, and dire wolves died out (became *extinct*) thousands of years ago. Yet, this picture of life—and death—around an ancient tar pit is probably accurate. From a study of *fossils* (the preserved remains of long-dead animals), scientists know that such struggles

After carefully putting together the skeleton of a saber-tooth (left), scientists figure out the size and shape of the animal's muscles. Eventually, they can make a good guess at what a live saber-tooth looked like (right).





robably took place about 15,000 years ago, in what is now outhern California.

The fossils were found in Rancho La Brea (which means ranch of tar" in Spanish), a place where oil oozes up to he surface and slowly thickens into tar and asphalt. Today ou can still see part of the La Brea tar pits. They have een saved as a park in downtown Los Angeles.

In 1906, a *geologist* (a scientist who studies the history f the earth) was examining the tar pits when he found ome bones. He suspected that they came from extinct animals and took them to Dr. John C. Merriam of the University of California. Dr. Merriam was a *paleontologist* (a cientist who studies animals and plants that lived long ago).

Dr. Merriam set to work as soon as he saw the fossils. Deep holes were dug in the tar, and thousands of bones and eeth were taken from La Brea. The bones were shipped to useums and laboratories where scientists could study them nd try to fit them together. In some cases, whole skeletons ere put together.

From the shape and size of the bones, paleontologists an figure out the shape and size of the muscles that were nce attached to the bones. An animal's teeth reveal whether was a meat or plant eater. From clues like these, paleontologists can get a picture of an extinct animal and the life lived (*see photo and diagram*).

What the Fossils Reveal

By studying the skulls of saber-tooth cats, for example, aleontologists learned that these cats stabbed other animals with their huge teeth. They could jerk their head and eeth back, ripping open the wound even more. Judging om the saber-tooth's thick bones and bulky build, these ig cats were extremely powerful.

Why did such strong creatures die out? No one knows or sure. But there were flaws in the makeup of the animal hich must have helped its downfall. Judging from its short legs, the saber-tooth must have been slower than most of the other meat-eaters of its day. It probably couldn't chase and catch swift horses and antelope. Instead it probably leaped from hiding, trying to catch slow-moving animals like ground sloths.

About 10,000 years ago, the climate of North America changed as glaciers pushed down from the north. This may have caused the death of some of the large, plant-eating animals. Also, early men had reached North America. They hunted sloths, mammoths, and other slow-moving plant-eaters. When these animals died out, so did the saber-tooths. The world was changing, but they did not change with it ■

Animals like this ground squirrel are still being trapped in the sticky tar at La Brea. Part of the tar pits has been saved as a park in Los Angeles.

■ A good book about prehistoric animals and how they are studied is **From Bones to Bodies: A Story of Paleontology,** by William Fox and Samuel Welles, Henry Z. Walck, Inc., New York, 1959, $3.

WHY IS IT SO?

Think of the numbers of different kinds of animals living today. There are many more plant-eaters, such as mice, rabbits, and deer, than meat-eaters, such as foxes, hawks, and weasels. Can you figure out why? In the La Brea tar pits, most of the fossils found were of meat-eating animals. Do you think the meat-eaters were more common in those days? Can you think of another reason for many meat-eaters visiting the tar pits?

BACK YARD MASTODON

The day after they saw a classroom film on fossils, two New Jersey boys found three large teeth and suspected that they had made a valuable find. They were right!

■ The chances of finding a prehistoric mastodon in your back yard are pretty slim, but that is just what happened to two boys in Hackensack, New Jersey, in 1962. It was a cold day in January—cold enough for James DiFranco, then 14 years old, and John Versace, then 15, to think about ice skating. They decided to test the ice in a drainage ditch behind the gas station owned by Jim's father.

As the boys were probing the ice with sticks, they found three bony objects that looked like large teeth, half buried in the mud bank. Only the day before, their class at State Street Junior High School had watched a film on fossils, and the boys were sure that they had found the fossil teeth of some prehistoric animal.

Neither Jim's parents nor John's thought that the teeth were those of an ancient animal, but the boys took them to school the next day. Their teachers agreed with the boys, and the next day their science teacher, Richard Straubel, took them to The American Museum of Natural History in New York City to have the fossils identified.

They went to the office of Dr. Edwin H. Colbert, who is Chairman of the Museum's Department of *Vertebrate Paleontology*. Scientists in that department study the prehistoric animals that had backbones. Dr. Colbert examined the teeth and confirmed that they were fossils—teeth from the lower jaw of an American mastodon. These elephant-like animals (*see above*) lived on the North American continent in the last million or so years. They died out about 8,000 years ago. Fossil remains of mastodons have been found in many places in the United States, including a number in New Jersey. But Dr. Colbert said that complete skulls and good skeletons are rare finds.

Excited by their find, the boys dug some more in the ditch and soon uncovered another tooth and part of the lower jaw of the mastodon. They telephoned Dr. Colbert, who came to the site of the find with two fellow scientists from the Museum who live near Hackensack.

"It's possible that the entire skeleton is here," Dr. Colbert told the boys. But the scientist asked the boys to stop digging. He felt that someone who had more experience in handling fossils should take over the job when the ground softened up in the spring.

More Fossil Finds

Late in March, George Whitaker, another Museum paleontologist, began exploring the "dig." He used a small hand digger and a paint brush to remove the soil from the lower jaw of the mastodon. While digging, he found two more of its teeth. Whitaker continued to dig on evenings and weekends, often with the help of the boys who had discovered the site. Later, he was helped by other Museum scientists, an amateur with some fossil-digging experience, and even some high school and college students.

In the next eight months, the diggers recovered the mastodon's teeth, jaw, four-foot-long tusks, pelvis, and parts of its skull, backbone, and ribs. They found all of its major bones except the legs. They also found fossil remains of many smaller animals—deer, elk, muskrats, rabbits, snails, snakes, turtles, birds, toads, frogs, fishes, moles, beavers, mice, and an extinct species of pig. These were scattered among and around the mastodon bones.

They even found some human remains close to the mastodon bones. There were three skulls, some other bones, some crude hunting tools, and some bits of charred wood that were probably from a campfire. Could these be the remains of prehistoric Indians who lived at the same time as the mastodon, and perhaps killed it?

he photo at the right shows John Ver-
ace, left, and James Di Franco digging
 the ditch where they had accidentally
ound three mastodon teeth in January
962. They soon found another tooth
nd the extinct animal's lower jawbone.
ater, George Whitaker, of The American
luseum of Natural History, uncovered
e mastodon's four-foot-long tusks
ee *photo at far right)* and all of its
ther major bones except the legs.

Scientists can often make a good guess about the age of a fossil by studying the layer of rock or soil in which it is found and the layers above and below it (*see "The Tell-Tale Dust," page 14*). But these fossils, including various parts of the mastodon skeleton, were spread out helter-skelter in the sandy soil on the sloping side of the ditch as well as at the bottom of it. This led the scientists to suggest that the bones of the mastodon, the Indians, and the other animals had been deposited at various times near the top of the ditch. Then, much later, they had all been washed down the slope at one time by a flood of water, perhaps caused by heavy rains.

Dating the Fossils

Since no other mastodon remains found in North America are less than about 8,000 years old, the scientists believe that the Hackensack mastodon died at least that long ago. Some of the smaller fossils at the site were those of animals known to have lived 10,000 to 12,000 years ago.

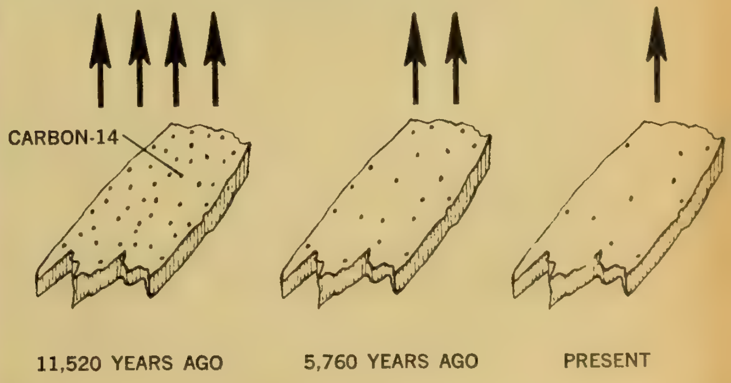
The scientists also measured the amount of radioactive carbon-14 left in the charred wood (*see "Dating Fossils by Radioactivity"*). From their findings, they judged that the charred wood was no more than about 2,500 years old, and that the Indians had lived thousands of years later than the mastodon.

During the fall, work had been delayed on a new expressway beside the fossil site. But the following spring, the site had to be filled in with earth so that the expressway could be completed. The mastodon's remains were stored at The American Museum, and this year the people of Bergen County, where Hackensack is located, raised $7,500 to pay the cost of putting the bones together for display. Soon it will be possible to visit the new Bergen Community Museum and see the Hackensack mastodon, whose 8,000-year-old fossil remains were found by two boys in a back yard ■

Dating Fossils by Radioactivity

Living plants take in from the earth's atmosphere a rare type of carbon called *carbon-14*. Carbon-14 slowly but constantly changes into another element, nitrogen-14. As the carbon-14 in a living plant changes into nitrogen-14, it is replaced by more carbon-14 from the atmosphere. Animals also take in carbon-14 from the plants they eat.

When a plant or animal dies, it stops collecting carbon-14. The amount of carbon-14 in the remains of the plant or animal gets smaller as it changes to nitrogen-14. No matter how much carbon-14 a dead plant or animal may have, it takes 5,760 years for half of its carbon-14 to disappear. (This period of time is called the *half-life* of carbon-14.) It then takes another 5,760 years for half of the remaining carbon-14 to disappear, and so on *(see diagram)*. By measuring how much carbon-14 is left in a piece of wood, for instance, scientists can figure out how long ago the wood was part of a living tree.



EXPLORING for FOSSILS

by Christopher J. Schuberth

You can find traces of ancient life anywhere in the United States. Here is how to find, collect, and study the fossils in your area.

■ Long before humans appeared on the earth, many different plants and animals were already living. We know that such plants and animals lived in the past because they left behind telltale marks—*fossils*. Some fossils are only impressions of a plant or animal. Others are the actual remains of an animal that have turned into stone. Still others are simply footprints, or even worm borings.

Where To Look for Fossils

You can find fossils almost anywhere in North America. The important thing is knowing *where* to look. How often have you passed an old quarry, or rock outcrops along highways, or rock exposed at the bottom of a creek? These are the kinds of places where you may find fossils—places where rock of the earth's crust is exposed.

Unfortunately, not all exposed rocks contain fossils. You'll find fossils only in those rocks that were once *sediments*—mud, lime, or sand deposits on the floor of an ancient sea, or sand and mud left behind by long vanished rivers and lakes. Many different kinds of animals and plants once lived, died, and were soon buried in these sediments. As time went on, more and more sediments settled over the older ones. Eventually, these were compressed and cemented into hard rock. Of course, not *all* sedimentary rocks contain fossils. At some times and places long ago, there were few or no plants and animals living that could have become fossils.

The first thing to do is to find where sedimentary rocks are exposed in your area. Shale, sandstone, limestone, and conglomerate are the common kinds of sedimentary rocks, and the key on page 7 will help you identify them. The books listed at the end of this article will also help you identify the kinds of rocks and fossils where you live.

Tips on Collecting Fossils

Before you set out for a likely fossil-collecting spot, you should get some collecting equipment. A hammer is needed, and a bricklayer's hammer works very well. Also get one or two medium-sized tempered cold steel chisels, a knapsack, some old newspapers, adhesive tape, a ballpoint pen, a good map, a few pill bottles with cotton to hold small or delicate specimens, and a magnifying glass.

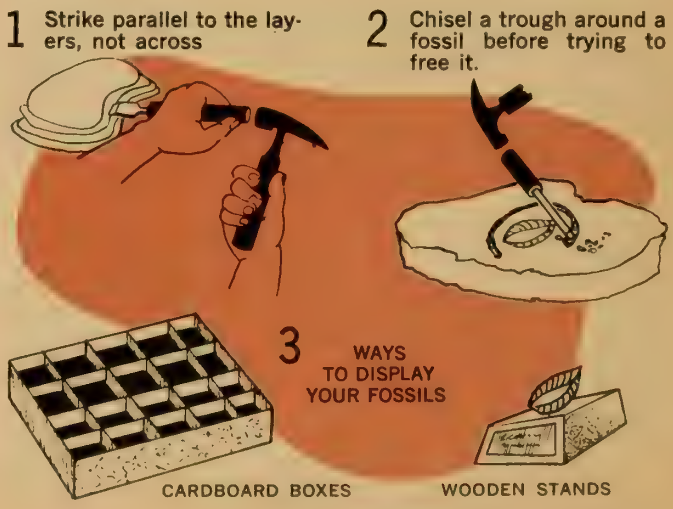
Wrap each specimen you collect in newspaper and tape the ends together. On the adhesive tape write down a number and the date collected for each fossil. In a little notebook write down the number and date for each fossil. Also write a short description of the fossil (or its name if you know it), the kind of rock in which it was found, and *where* you found it. An up-to-date map will help you locate your fossil-collecting sites. Much of the value of a fossil is lost if you do not have this information.

Get down on your hands and knees or just sit in one spot and look around carefully. Many valuable fossils have been found in places where others have searched many times.

When you use your hammer and chisel to split sedimentary rocks, always strike them parallel to the layers, not across *(see Diagram 1)*. It is on the broad flat surfaces that fossils occur. Many fossils cannot be removed from rock without being destroyed. In these cases, trim the rock with its fossil down to a small size. Then wrap the specimen in newspaper, number and date it, and take it home. Later, you may be able to free the fossil without damage.

Preparing Your Fossils

When you take your specimens home, unwrap them, making sure that the numbered adhesive tape is not mis-


1 Strike parallel to the layers, not across
2 Chisel a trough around a fossil before trying to free it.
3 WAYS TO DISPLAY YOUR FOSSILS
CARDBOARD BOXES
WOODEN STANDS

placed. Put each specimen in water to soak overnight. Then use a stiff toothbrush to remove excess rock and soil. You can also use long needles, tweezers, and old dental picks from your dentist to clean around the smaller parts of your fossil.

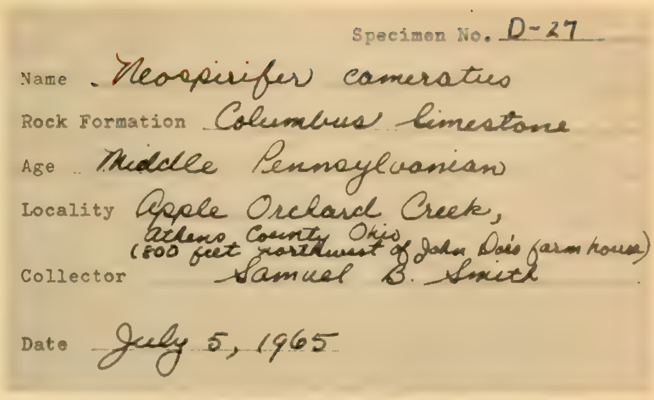
Next, try to free fossils from the rock. Do this by chiselling a narrow trough completely around the fossil. Be sure to point the chisel *away* from the fossil; if you don't, you will probably split the specimen. When the trough is just a little deeper than the fossil, strike at the fossil's base with a chisel; the fossil should be freed *(see Diagram 2).*

After preparing your fossils, they should be labeled. Perhaps you can group together all the fossils from one area. With a fine-pointed pen and India ink, number each fossil from that area (1, 2, 3, and so on). Give each area a letter and write the letter on each fossil, too. This letter and number combination is called a *catalog number*.

Next, make a paper label to go with each specimen. On the label should be the catalog number, plus most of the information from your notebook *(see sample).* Finally, make a set of *catalog cards,* using a 3-by-5-inch file card for each fossil. Write on each card all the information you have in your field notes, plus any information you have from books and other sources. Arrange these catalog cards in numbered order. Make a different set of cards for each collecting area. All this may seem like a lot of work, but a fossil without such information is little more than a curio. If you keep good records, your fossils will have real scientific value.

You may need help in identifying a few of your fossils. The drawings on the next two pages will help you identify some fossils of the common animals without backbones. You can also get help from natural history museums and geology departments of local colleges and universities. Perhaps a science teacher in the high school can help you.

SAMPLE LABEL



Specimen No. D-27
Name Neospirifer cameratus
Rock Formation Columbus limestone
Age Middle Pennsylvanian
Locality Apple Orchard Creek,
Athens County, Ohio
(800 feet northwest of John Doe's farm house)
Collector Samuel B. Smith
Date July 5, 1965

There may be a club of fossil or mineral collectors near your home. By joining such a club you will meet people who can identify your fossils or tell you where to get help. But most important of all, look for books about fossils in your library *(see the book list below).*

You will need quite a bit of room to display your fossils. They can be placed on small wooden stands or in small boxes that you can make yourself *(see Diagram 3).*

With proper note-taking and care, your fossils will be much more than just a collection. They will be an avenue through which you can learn more about the past life of the fascinating planet on which you live ■

■ The best book to help you begin your study of fossils is **Fossils: A Guide to Prehistoric Life,** by Frank Rhodes, Herbert Zim, and Paul Shaffer, Golden Press, New York, 1962, $1. Another good book is **Exploring the World of Fossils,** by William H. Matthews III, Childrens Press, Chicago, 1964, $3.95. To identify rocks and minerals, see **Rocks and Minerals,** by Herbert Zim and Paul Shaffer, Golden Press, New York, 1957, $1; and **A Field Guide to Rocks and Minerals,** by F. H. Pough, Houghton Mifflin Co., Boston, 1960, $4.95.

HOW TO IDENTIFY COMMON SEDIMENTARY ROCKS

You can use this key to identify the four most common kinds of sedimentary rocks. Answer the question on line A by examining your specimen. Your "yes" or "no" answer will steer you to the next question to answer. Each question and answer will lead you to the name of the sedimentary rock.

A. Can you see individual particles of mineral or rock that make up the specimen without using a magnifying lens? **If yes, see line 1. If no, see line B.**

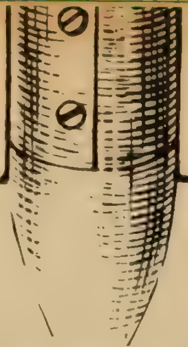
1. Is the specimen composed of rounded particles? **If yes, see lines a and b.**
   a. If the particles are large pebbles, the rock is ………… **CONGLOMERATE**
   b. If the particles are sand-sized grains of quartz, which will scratch glass, the rock is ………… **SANDSTONE**

B. If you cannot easily see the particles of minerals or rock without using a magnifying lens, see if the particles of rock are arranged in layers. Is the rock too soft to scratch glass? **If yes to all questions, see line 1.**

1. Does the rock split easily into layers? **If yes, see line a. If no, see line b.**
   a. If the luster on the split surface seems silky, the rock is **slate,** not a sedimentary rock. If the surface is dull, the rock is ………… **SHALE**
   b. If it does not split easily into layers, the rock is probably ………… **LIMESTONE**

nature and science WALL CHART

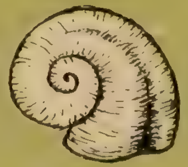
October 18, 1965



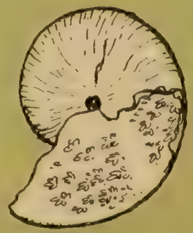
Fossils You May Find

■ The drawings on these pages show some of the common kinds of fossils you may find. Except for two plants, all the fossils shown are those of animals called *invertebrates*, or animals without backbones. Fossil animals with backbones, such as dinosaurs, are not as easy to discover as invertebrates. If you should find bones or other remains of vertebrate animals (or, for that matter, any other fossil that you think is rare), leave them intact and get help from an expert on fossils. Many valuable fossils have been ruined by persons not experienced in removing them.

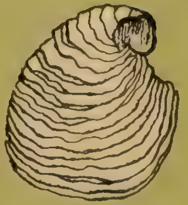
Compare the fossils you find with the drawings on these pages. The captions tell something about the animals' lives. With each drawing is a label giving its scientific name, telling where you might find the fossil, and naming the period in which the plant or animal lived. Use the time scale at the bottom of the pages to find out the age of the fossil ■



Platyceras niagarense
(a Gastropod)
lived in the Silurian Period
found in most of North America



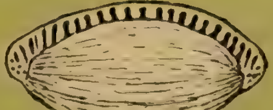
Phylloceras onoense
(a Cephalopod)
lived in the Lower Cretaceous Period
found in California



Exogyra Ponderosa
(a Pelecypod)
lived in the Lower Cretaceous Period
found in central United States

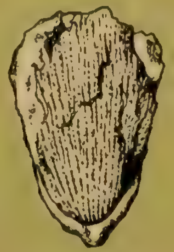
Mollusks are a larger group of invertebrate animals that have lived from the Cambrian Period to the present. Most of them are soft-bodied animals that are protected by a hard shell. They include snails (*Gastropods*) which have a coiled shell of one chamber. Another group, the *Pelecypods*, includes clams, oysters, and mussels. The last important group of fossil mollusks is the *Cephalopods*. Some of the best-known living cephalopods are the squid and the octopus. Most fossil forms had well-developed shells.

Some of the most common kinds of fossils are those of tiny, one-celled animals (*Protozoa*). The fossil shown here is from a group called *Foraminifera*. "Forams," as they are called, usually live in the sea. They have shells that become fossils when the forams die. These fossil shells can be found in rocks that range in age from the Ordovician Period to recent times.



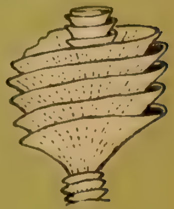
Fusulinella
lived in the Pennsylvanian Period
found in most of North America

"Moss animals," more complex than corals, are in a group called *Bryozoa*. Each animal is only a fraction of an inch long, but bryozoans live in large underwater colonies. These colonies have become fossils and are found in rocks from the Ordovician Period to recent times.

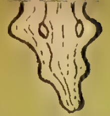


Lyropora subquadrans
lived in the Lower Mississippian Period
found in the Mississippi Valley

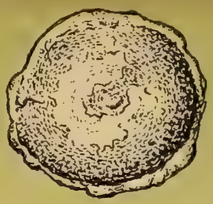
Archimedes wortheni
lived in the Mississippian Period
found in Illinois



Corals, sea anemones,

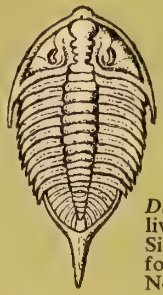


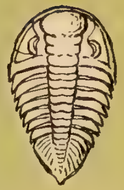
Hydnoceras bathense
lived in the Lower
Devonian Period
found in western
United States



made of many pores, canals, and chambers, supported by thin skeletons which are often found as fossils. Sponges have lived from the Pre-Cambrian Era to the present.

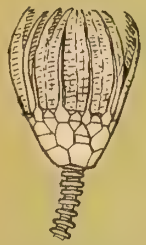
The *Arthropods* include over a million different kinds (*species*) of animals. Spiders, lobsters, insects, and millipedes are all arthropods. One of the most spectacular and most sought-after kinds of fossils from this group are the trilobites. These animals ranged in size from a quarter of an inch to 27 inches long. They lived only in seas of the Paleozoic Era.



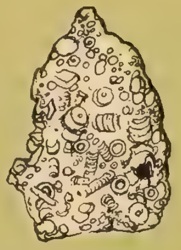


Odontochile
lived in the Devonian
Period
found in most of
North America

Dalmanites limulurus
lived in the Middle
Silurian period
found in eastern
North America

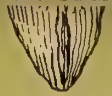


Eucalyptocrinites crassus
lived in the Silurian
Period
found in central
United States



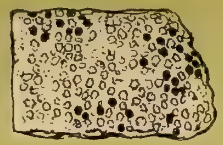
stems of crinoids
lived in the Mississippian
Period
found in most of
North America

"Spiny-skinned animals," or *Echinoderms*, include such sea animals as starfish, sea "lilies," and sand dollars. Parts of sea lilies, or *crinoids*, are common fossils. What is usually found is a fossil of the jointed stem that held the animal to the ocean floor. Crinoids were especially abundant in Devonian and Mississippian times and can be found in rocks going back to the Cambrian Period.



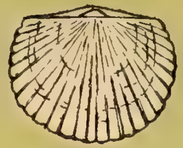
Aulacophyllum sulcatum
lived in the Middle
Devonian Period
found in central
United States

North America



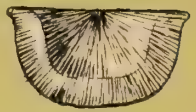
fossil corals are shown here. The fossils found are usually hard skeletons, not the soft-bodied animals that once lived inside the skeletons. Corals have lived from the Ordovician Period to the present.

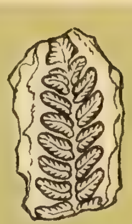
Brachiopods are the most common fossils in many areas. They are made of two shells that once enclosed the soft parts of the animal. The shells vary greatly in size and shape. Brachiopods have lived in shallow sea water from the Cambrian Period to the present.



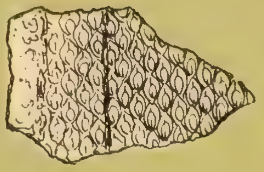
Dinorthis pectinella
lived in the Middle
Ordovician Period
found in eastern
United States

Chonetes coranatus
lived in the Middle
Devonian Period
found in most of
North America





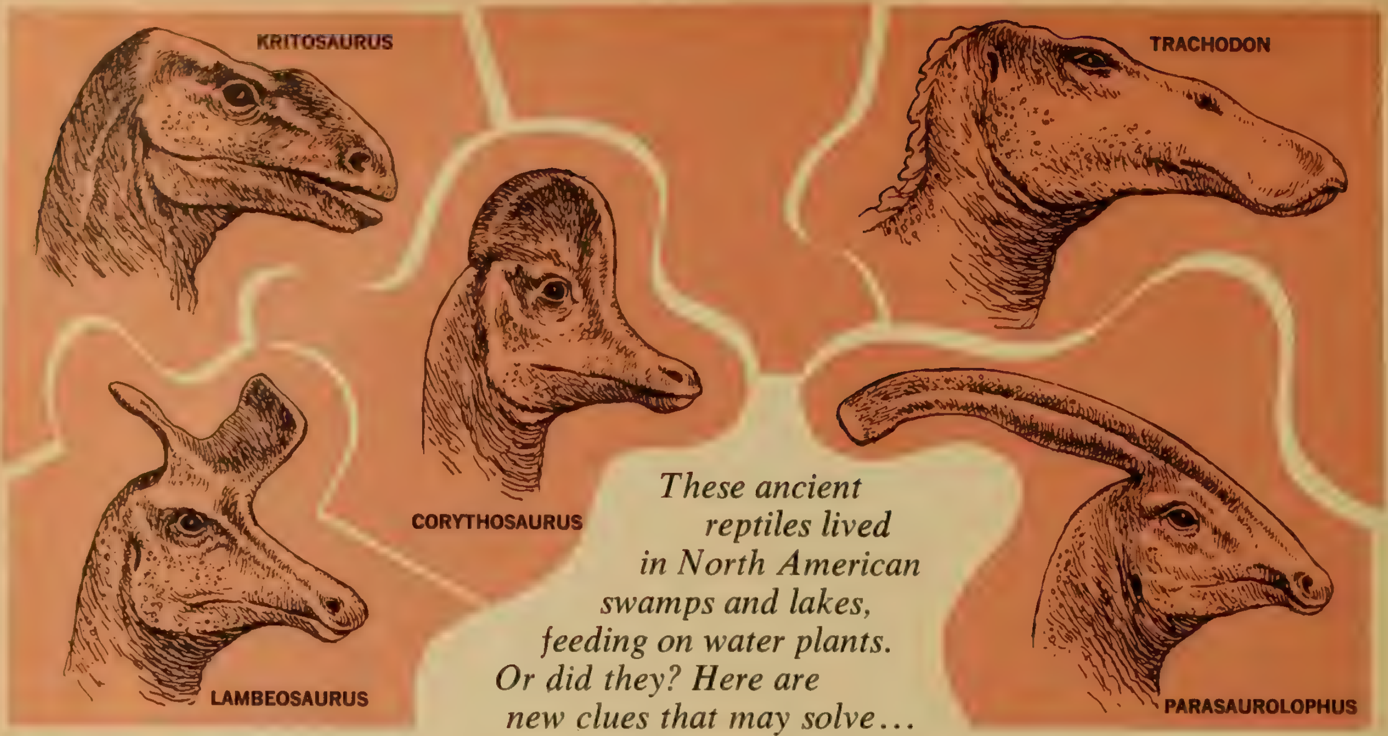
Neuropteris
lived in the Mississippian-
Permian Periods
found mostly in eastern
United States



Lepidodendron
lived in the Pennsylvanian
Period
found mostly in eastern
United States

Plants have many soft parts and so do not often become fossils. They may be important clues to the climate of past ages. The fossil shown on the right is from a group called the *Lycopods*, a kind of large tree that was abundant during the late Paleozoic Era. These fossils are often found in areas where there are coal deposits. The fossil on the left is from a group of plants called *seed ferns*, which died out in the Jurassic Period.

PERIOD	RE-CAMBRIAN 70 million to ,500 million years ago	CAMBRIAN 500 million to 570 million years ago	ORDOVICIAN 435 million to 500 million years ago	SILURIAN 395 million to 435 million years ago	DEVONIAN 345 million to 395 million years ago	PENNSYLVANIAN MISSISSIPPIAN 280 million to 345 million years ago	PERMIAN 225 million to 280 million years ago	TRIASSIC 193 million to 225 million years ago	JURASSIC 136 million to 193 million years ago	CRETACEOUS 65 million to 136 million years ago	TERTIARY 1.5 million to 65 million years ago	QUATERNARY present to 1.5 million years ago
ERA		PALEOZOIC						MESOZOIC			CENOZOIC	



These ancient reptiles lived in North American swamps and lakes, feeding on water plants. Or did they? Here are new clues that may solve…

the duck-billed dinosaur puzzle

by John H. Ostrom

■ A little more than a century ago the first skeleton of a North American dinosaur was discovered. The place was southern New Jersey, not far from Philadelphia. The time was 1858, shortly before the Civil War. The dinosaur? We now know it by the scientific name of *Hadrosaurus foulkii* —one of the duck-billed dinosaurs that lived more than 70 million years ago.

Since that discovery, the remains of many hundreds of different kinds of dinosaurs have been found in North America. Among the most common kinds found are the duck-bills—so called because of their broad duck-like beaks. Toward the end of the Age of Dinosaurs, duck-billed dinosaurs were very abundant. Some kinds of duck-bills had heads shaped like *Hadrosaurus*. Others had strange, hollow, bony crests on top of their heads. Still other kinds, like *Saurolophus*, had solid, bony spikes atop their heads. The duck-bills are well known to anyone who has read about or studied dinosaurs. Most books say that these particular dinosaurs spent a great deal of their time in water, swimming about in lakes and swamps and feeding on water plants.

But did they?

Are you really sure? I'm not. In fact, I think there are a number of reasons why we should think about this matter all over again. We should look once more at the evidence that has led to the idea of duck-billed dinosaurs living and feeding in the water. Just how good is the evidence? Are there any good reasons for doubting it?

An Idea Is Born

The idea that duck-billed dinosaurs were *amphibious*—living both on land and in water—was born shortly after the discovery of the *Hadrosaurus* skeleton. In fact, it was this very discovery that started the whole idea. The bones of *Hadrosaurus* were taken to a scientist, Dr. Joseph Leidy of the Philadelphia Academy of Sciences. Because this was the first discovery of dinosaur remains in North America (dinosaur skeletons had been found only in Europe before this time), Dr. Leidy made a very careful study of the bones. When he presented his report to the Academy in December 1858, Dr. Leidy commented briefly about how he thought this animal had lived: "*Hadrosaurus* was most probably amphibious." This remark was the beginning of the notion that duck-billed dinosaurs were fond of water.

Today, more than a century later, this idea is accepted by all, or nearly all, scientists. Unfortunately we don't know exactly why Dr. Leidy came to believe this idea. No particular reason was given in his report. Whatever the reason, Dr. Leidy started us thinking about these animals as swimmers right from the very start, with the first duck-billed dinosaur found.

More "Evidence"

Several other skeletons and parts of skeletons of duck-billed dinosaurs were found during the next few years. However, nothing more was said about the way these animals might have lived until 25 years later. In 1883, another prominent scientist and member of the Philadelphia Academy, Edward Drinker Cope, reported on some new duck-bill finds.

In describing a nearly complete skeleton now on display in The American Museum of Natural History, he noted that it had a delicate beak and small, delicate, and loosely attached teeth. With teeth like these, Cope reported, this animal could only have eaten soft vegetable matter. He supposed this to have been soft water plants without any hard, woody tissue. He suggested that *Anatosaurus* had waded about in ancient lakes, grubbing about the muddy bottoms with its duck-like beak and pulling up underwater plants. From that moment on, the idea of underwater feeding in lakes and swamps has always been applied to the duck-billed dinosaurs.

In 1906, Barnum Brown (of The American Museum of Natural History) discovered a complete duck-bill's tail with large flat sides preserved as skin impressions. This discovery convinced more people that duck-bills spent most of their time in water. After all, why would an animal's tail be flat-sided if it was not used for swimming?

Remarkable discoveries in 1908 of two more duck-bills seemed to decide the questions once and for all. These two skeletons showed that the "hands" were shaped like mittens. The fingers were not separated as they are in our hands, but were held together by a mitten-like covering of skin. Duck-bill hands were rather like paddles. This discovery led Henry Fairfield Osborn of The American Museum of Natural History to conclude that the "hands" and forearms of duck-billed dinosaurs were used for swimming and not for walking. Osborn published these conclusions in 1912, and since that time almost no one has questioned this watery way of life.

A Dinosaur with a Snorkel?

The first crested duck-bill *(Lambeosaurus)* was not discovered until 1914. Some years after its discovery, a scientist found that the head crest of *Lambeosaurus* was not made of solid bone, but was hollow. Also the hollow parts of the crest were connected to the nose passages *(see next page)*. People tried to explain how the hollow crest was related to the watery habits of duck-bills.

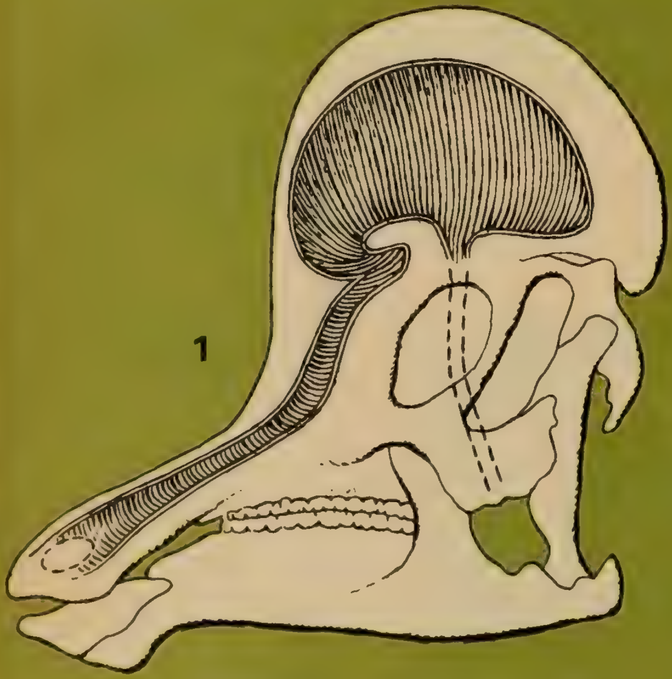
One theory suggested that the dinosaur's nostrils had been located at the top of the crest, making a snorkel-like gadget so these animals could breathe while under water

(Continued on the next page)

This man is carefully digging a fossil duck-bill from the ground. It was discovered in 1910 by Dr. Barnum Brown of The American Museum of Natural History. Found in Montana, this Trachodon dinosaur is one of many fossil duck-bills discovered in North America.

1 **One of the most puzzling things about duck-bills is their unusual head crests. Several duck-bills, including Corythosaurus (below) and Lambeosaurus had hollow crests that were connected with the dinosaur's nose. So far, no one knows how the crests were used.**

2 **This is a photograph of the jaw bone of a duck-bill, showing the hundreds of teeth that could be used to grind up hard plant foods.**



just by poking the top of the crest out of water. Another theory suggested that the crest cavity acted as a trap and kept water from going up the nose and into the lungs while these animals fed under water. Still another idea was that the hollow crests stored an extra supply of air so the animal could stay under water longer. Any one of these theories fits well with the watery way of life that duck-bills were thought to have lived.

Another Look at the Duck-Bills

But did the duck-billed dinosaurs really live and feed in lakes and swamps? Let's look at the evidence again. This time, let's look at *all* the evidence before making up our minds. Leidy and Cope could not do this. They did not have many of the most important specimens when they wondered about the lives of the duck-bills.

There are several features about these dinosaurs that do not seem right for animals that supposedly spent most of their time in the water. First of all, Cope was mistaken about the teeth of duck-bills. They were not delicate. Nor were they loosely attached. The teeth of duck-bills were firmly attached to the jaw bones—more firmly attached than in any other dinosaur. Moreover, both upper and lower jaws were filled with some 200 or 300 teeth tightly packed together to form large grinding surfaces. Scientists have recently discovered that these large groups of teeth operated with a forward and backward grinding action, like the teeth of beavers and many other plant eaters. It seems that the duck-billed dinosaurs had special teeth for grinding up hard foods. Teeth like this would not be needed to grind up soft water plants.

In 1922, a German scientist examined some fossil plant remains that had been found *inside* a duck-bill. These plant remains were probably the last meal of that animal. What kinds of plants were found? Surprisingly, most of the identifiable remains were the needles of pine trees—not soft water plants.

At that time, the pine needles were explained as the nibblings of a duck-bill that had wandered away from its usual home. However, we are much more likely to find the remains of common animals than those of unusual ones. It is more likely, therefore, that most or all duck-bills fed on pine needles, as this one animal did. The pine needles would have to be ground up for digestion, and at least this particular dinosaur had to roam about on dry land to find pine needles to eat. Certainly others could also have done this, and probably did.

Crests, Tails, and Paddles

If duck-billed dinosaurs didn't feed on water plants in lakes and swamps, why did they have those strange crests, the flat tails, and the paddles? What about those hollow crests that are thought to have served as snorkels? Or water traps? Or air storage chambers? Recent studies show that not a single one of these was possible. For example, the snorkel idea is ruled out because none of the crests of the duck-billed dinosaurs have any nostril-like openings at their tops. Of course, this does not prove that duck-bills did not live in the water. But we can no longer point to these head crests as evidence that duck-bills did live in water.

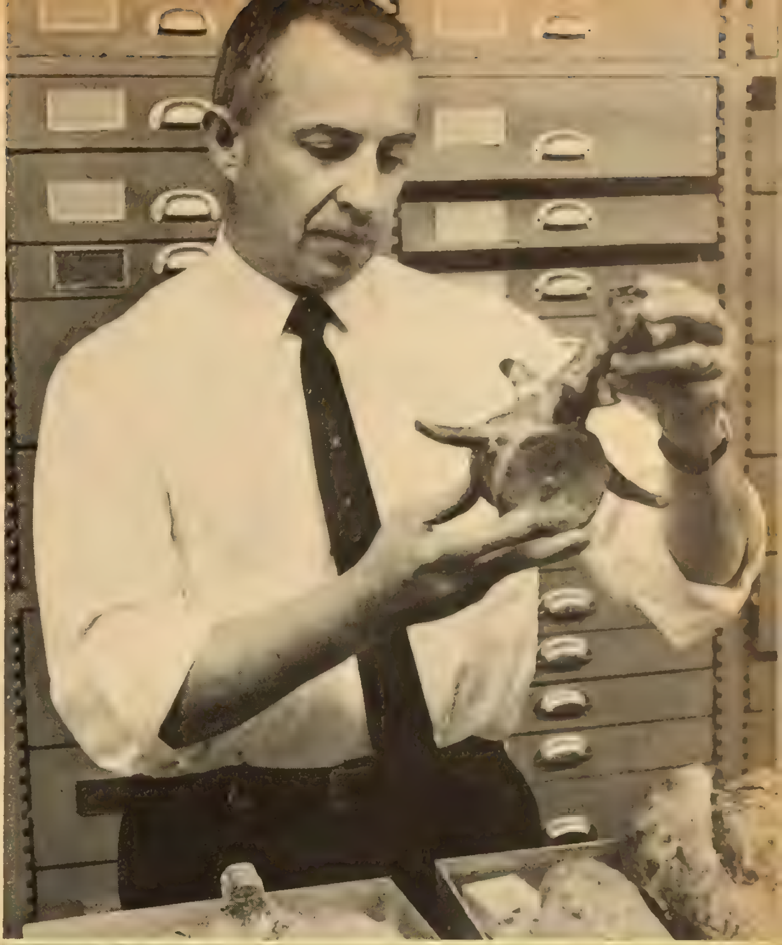
What about the flat tail? Tails for swimming are flat-sided; does that mean all flat-sided tails are for swimming? And do we know for certain that the duck-bill tail was really flat? All we know is that it was very deep from top to bottom. This is a sign that it was a large, and possibly heavy tail—just what was needed to balance the weight of the large body and head while the dinosaur was standing or walking in two-legged fashion. There is no proof that it was a flat-sided swimming tail. In fact, the strong bones in the tail hint that, flat-sided or not, the tail was too rigid for swimming.

What about the mitten-like "hands"? Could these have been used to paddle along in the water? Yes, they could. But, compared with the size of the animal, they were rather small for paddling it anywhere. And these could just as well have served as broad foot pads for supporting the animal on soft, swampy ground.

We really don't know all the answers yet, but certain things do seem clear. We know from fossil plants found with the remains of duck-billed dinosaurs that these creatures lived in lowland forests near swamps and rivers. From plant remains actually found *inside* one duck-bill skeleton, we know that some duck-bills ate land plants—evergreens in particular. We know from study of their teeth that they were well equipped for grinding hard plant tissues. From the structure of their limb bones and backbone, we know that the duck-bills were good at walking about on land, and that they were *not* very good at swimming, at least with their heavy tails. We also know that the strange, hollow crests were not helpful for life in the water (although we still cannot say exactly what they were used for).

Perhaps duck-bills did swim some. After all, most animals do. Perhaps they swam across rivers or swamps in search of fresh trees to feed on. Or perhaps they fled to the water to escape from meat-eating dinosaurs like *Tyrannosaurus*. But I think the duck-billed dinosaurs were land animals. I believe that they spent most of their time munching on evergreens along river banks and lake shores of ancient North America.

What do you think? ■



Did you see the dinosaur exhibit at the 1964-65 New York World's Fair? The author of this article, Dr. John H. Ostrom, gave advice about dinosaurs to the company that showed life-size models of dinosaurs. The models included two duck-bills, Trachodon and Corythosaurus.

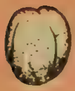
The photo above shows Dr. Ostrom looking at a fossil backbone of a dinosaur. In recent years, he has searched for dinosaur fossils in Montana, Wyoming, Alaska, and many other western states, as well as in Canada. Two dinosaurs that were discovered on his last expedition to Montana are still being studied.

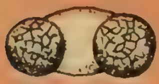
Dr. Ostrom is Assistant Curator of Vertebrate Paleontology of the Peabody Museum of Natural History at Yale University. He lives in Hamden, Connecticut, with his wife and 6-year-old daughter, Karen Ann.

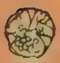
■ Look for these books about dinosaurs in your library or bookstore: **Dinosaurs and Other Prehistoric Reptiles,** by Jane W. Watson, Golden Press, New York, 1960, $2.95; **All About Dinosaurs,** by Roy C. Andrews, Random House, Inc., New York, 1953, $1.95; **The Rise and Fall of the Dinosaurs,** by Anthony Ravielli, Parents' Magazine Press, New York, 1963, $2.95; **Dinosaur Hunt,** by George Whitaker, with Joan Meyers, Harcourt Brace & World, Inc., New York, 1965, $3.50.

the tell-tale dust

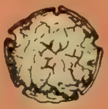
by Ghillean Prance and Richard M. Klein


OAK


PINE


WILLOW

Tiny pollen grains that once floated through the air are now being used to explore the history of the earth and its life.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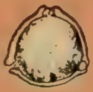
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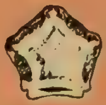

ALDER

■ If you could follow an airborne pollen grain, where would it lead you? Each year, many millions of these tiny grains are shed by flowers—to be blown by the wind to other flowers. However, very few of them ever reach flowers.

Some of these grains cover the surface of ponds like a fine yellow dust. Some irritate the inside of people's noses, giving them hay fever. Most pollen just falls to the ground. There it usually decays. If, however, it is covered with soil or settles in mud at the bottom of a pond, it may resist decay for thousands of years.

These long-buried pollen grains interest scientists who study past life on earth. For example, in the 1920s, Professor Johannes Iverson of the University of Copenhagen was studying fossil pollen in Denmark. As he dug deeper into the soil, he carefully collected pollen from each layer of soil. He was able to tell the age of the layers of soil—and of the pollen in it—by a method of "dating" that uses radioactive elements *(see page 5).*

In soil laid down about 5,000 years ago, he found pollen grains from such trees as alder, birch, pine, and oak. A little closer to the surface (in younger soils), he found more and more pollen from white ash trees. Then in soils laid down about 4,500 years ago, the tree pollen became scarce and Professor Iverson found a thin layer of charcoal. Above that he found pollen from weeds, birch trees, and cereal grasses (such as wheat, rye, and barley).

From the tiny pollen grains and other clues, Professor Iverson was able to piece together this picture of the past: About 5,000 years ago, the climate of Denmark began to get drier (white ash trees replaced trees that need more rainfall to grow). About 4,500 years ago, early man moved into the area from southern Europe. These people cleared the forests and burned them (leaving a layer of charcoal), and planted crops that they used for food (leaving pollen from cereal plants and the weeds that grew with the crops).

This is how the study of fossil pollen (called *palynology*) reveals information about the climate and life in prehistoric times. So far, scientists have used pollen grains to trace life back 80,000 years.

How To Find Fossil Pollen

Here is how a scientist goes about finding and studying fossil pollen. The first job is to locate an area where the layers of soil and pollen have not been disturbed. Some places are naturally better than others. The bottoms of lakes or deep ponds are favorite spots to dredge up samples. They have thick layers of sediment and mud, and pollen sifts into them easily. Bogs and swamps, which are old, filled-in lakes or ponds, are also good places to look.

The simplest way to get samples of fossil pollen is to start digging a deep pit or trench and to take small samples every few inches as you dig down. Another method (which is much easier on your back), is to use a soil *borer* or *auger (see diagram),* that can be pushed or twisted into the soil, and then pulled up bringing a cylinder of soil inside it. Once back in the laboratory, the cylinder is cut up into lengths. Each length may represent the soil that was the surface of the ground during, say, 500 years.

The fossil pollen is then taken from each soil sample. Chemicals, such as acids, are used to get rid of the rocks, pebbles, soil, decaying plant materials, and other stuff in the soil. Chemicals that do not destroy the fossil pollen are used. Eventually, all of the soil is removed. The pollen is concentrated into a drop of the almost colorless matter that is placed on a microscope slide and examined.

Dr. Prance is Research Associate in Taxonomy and Dr. Klein is Caspary Curator of Plant Physiology at The New York Botanical Garden.

All of the previous steps are easy compared with the next step. The scientist must not only count the tiny pollen grains, but he must identify the kind of plant from which they came. This is a tough job and one which requires a good deal of training and experience. Even the best pollen specialists still have trouble identifying *all* the kinds of pollen which they see through their microscopes *(see drawings of pollen grains on page 14).*

What the Pollen Reveals

Once a scientist knows how many pollen grains there are in a soil sample, how many pollen grains there are of each kind of plant, and how old the soil is, he usually prepares a *soil profile (see diagram).* It shows the kinds and abundance of trees and other plants found over the centuries in one area.

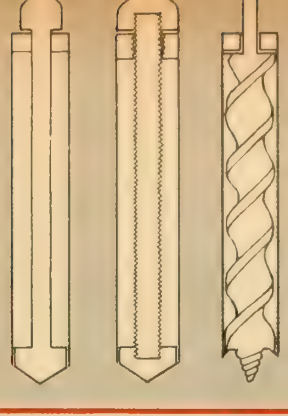
If the soil profile for 20,000 years ago shows a high number of pollen grains from spruce and fir trees, the climate must have been cool, as it is today in Maine and Canada. If oaks and hickorys were common 15,000 years ago, the climate was likely to have changed from cool to warm and dry. The clues from pollen studies also tell something about the kinds of animals in an area. Animals such as moose and sables would be found where spruce and fir trees grew because they are found in such areas today.

Study of fossil pollen has helped scientists picture the great changes in the climate and land of North America. In Arkansas and Mississippi, we have found the fossil pollen of plants that today live only in the arctic areas of northern Canada and Alaska. Fossil pollen from plants which today grow on the shores of the Pacific Ocean can be found in the hot, dry land of Utah and New Mexico. This shows that there must have been a vast inland sea covering Utah and the surrounding states.

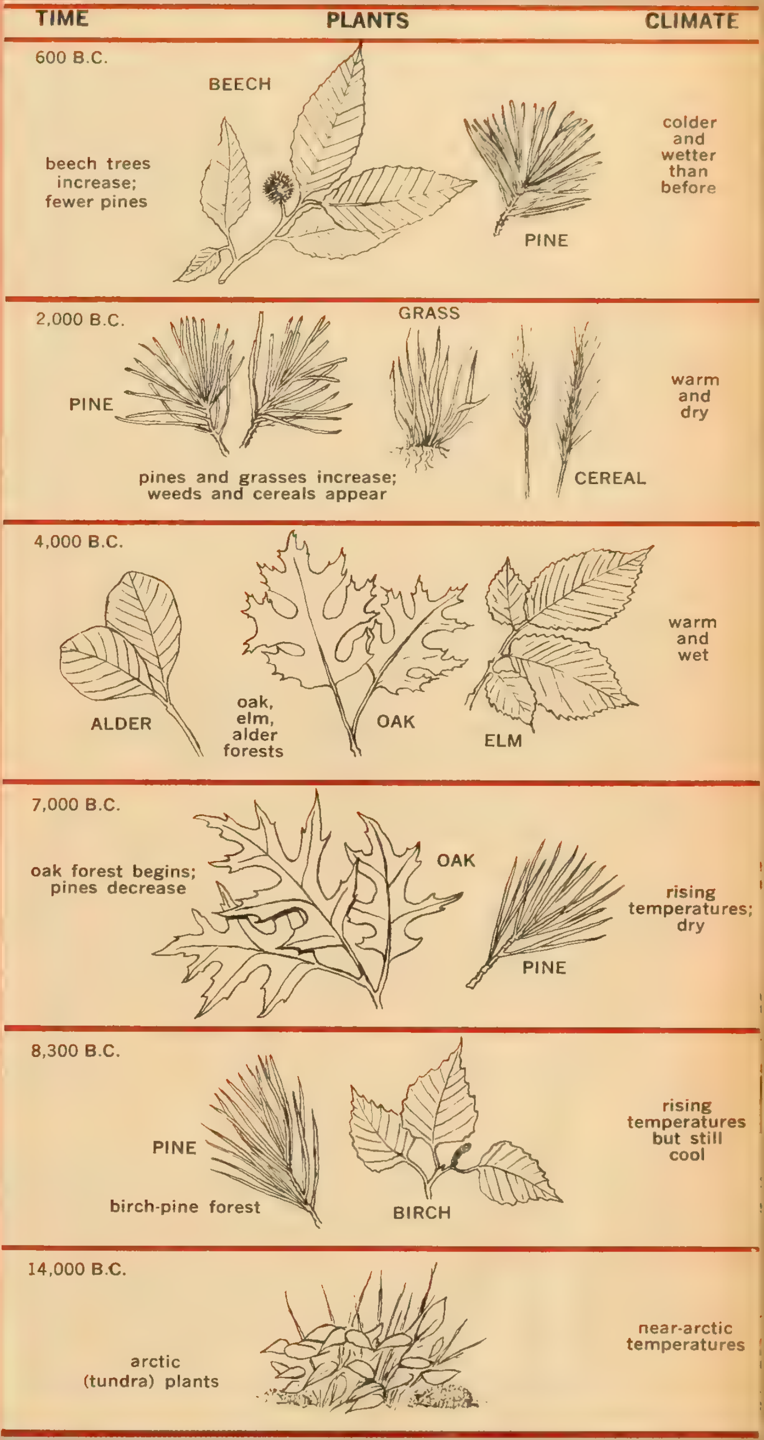
The discovery of fossil sea shells and skeletons of fish in the same area confirms the findings made with pollen. When all the clues of fossil animals, soil profiles, and pollen are put together, we have a clearer picture of the past, and perhaps a better understanding of the present and future ■

PROJECT

Look at some pollen grains under a microscope. First smear one side of a microscope slide with a thin layer of egg white. Wipe off the excess. Then dust the pollen from a flower onto the slide. The pollen grains will stick to the egg white. Examine them under both low and high power lenses. Look at pollen from other flowers and try to tell one kind of pollen grain from another. Gradually, you will be able to identify different kinds of trees, shrubs, and flowers by their pollen.



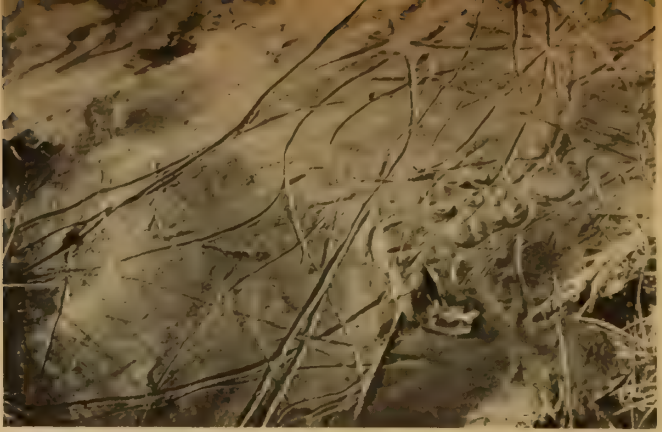
These drawings show three different kinds of augers that are used to collect a cylinder of soil. The drawings and labels below show what can be learned by studying the pollen found in different layers of soil.


TIME
PLANTS
CLIMATE
600 B.C.
BEECH
beech trees increase; fewer pines
PINE
colder and wetter than before
2,000 B.C.
GRASS
PINE
pines and grasses increase; weeds and cereals appear
CEREAL
warm and dry
4,000 B.C.
ALDER
oak, elm, alder forests
OAK
ELM
warm and wet
7,000 B.C.
oak forest begins; pines decrease
OAK
PINE
rising temperatures; dry
8,300 B.C.
PINE
birch-pine forest
BIRCH
rising temperatures but still cool
14,000 B.C.
arctic (tundra) plants
near-arctic temperatures

By studying fossil pollen, scientists have been able to put together this picture of changes in the plant life and climate of northern Europe over thousands of years.

brain boosters

prepared by DAVID WEBSTER

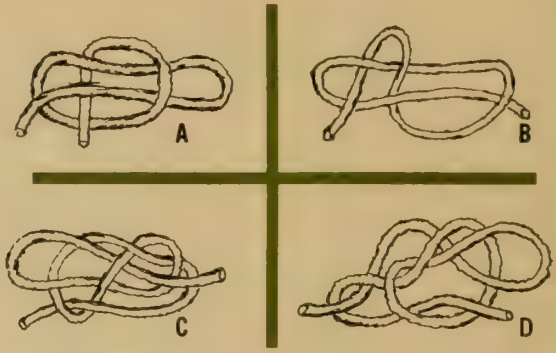


MYSTERY PHOTO

The marks shown in this photo of the bank of a stream sometimes become fossils. What are they?

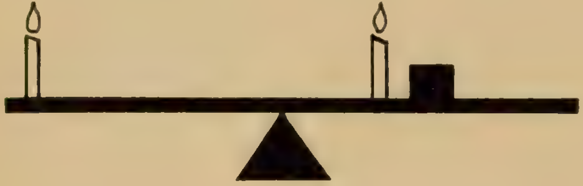
Can you do it?
What is the secret message?

T H H E U N
A T B A C E
S T L L S
H E B O
W A
Y T



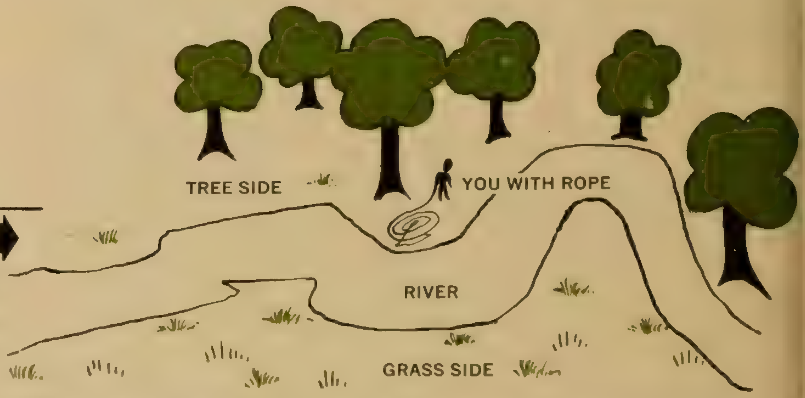
Fun with numbers and shapes
Suppose the ends of each of these tangled strings are pulled. Which strings will end up without knots? Which will have knots? What will the knots look like?

What would happen if . . . ?
Last year in Brain-Boosters we had a question about burning candles on a balanced stick. Here is another problem with balancing candles. Notice that the candles are different distances from the balance point, and that a metal block has been placed on the right side to make the stick balance. What will happen as the candles burn? Will the stick still balance?



For science experts only

Trees grow along one side of this swiftly flowing river, but the other side is flat land with no trees. You are on the wooded side of the river, and you have a very long rope. Can you get across the river to the side with no trees without getting wet?



Submitted by Tony Evers, Lucerne, Switzerland

Answers to Brain-Boosters appearing in the last issue

Mystery Photo: The space between the top magnets is larger than the space between the bottom ones. The lower magnets are closer together because the magnets above them are pushing them downward. What would happen if you put another ring magnet on the stick?

Can you do it? To make the root and stem of a seedling curve, turn the "seed sandwich" on its side after the seed has grown about an inch.

What would happen . . . ? If a plastic bag is held over your hand, your hand should soon begin to feel hot,and sweat. Moisture also collects inside the bag.

Fun with numbers and shapes: You can put six quarters around another quarter. Only seven dimes will fit around a 25-cent piece.

For science experts only: There is a small amount of water inside a kernel of popcorn. When the popcorn is heated, the water turns to steam and explodes the corn.

Have you an idea for a Brain-Booster? Send it with the solution to David Webster, R.F.D. #2, Lincoln, Massachusetts. If we print it, we will pay you $5. Be sure to send your name and address. If several readers submit the same idea, the one that is most clearly presented will be selected. Ideas will not be returned or acknowledged.

l,

nature and science wall charts

Our Ocean of Air (201)

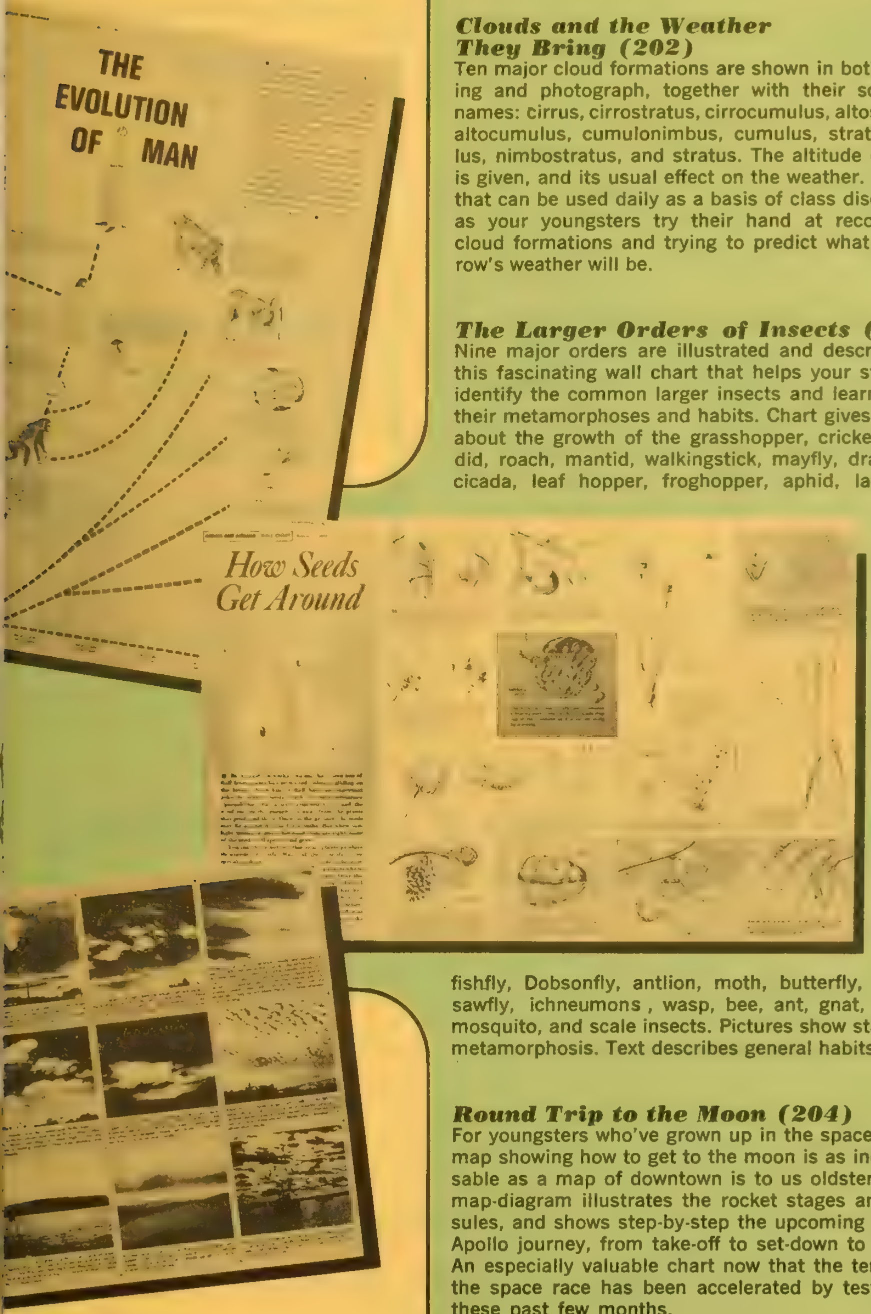
Scientists today think of our atmosphere as a vast spherical "room"—furnished with both natural and man-made objects. This chart shows major forms of "furniture"—from high-flying birds (5 miles up) to the Tiros Weather Satellite (466 miles). Chart indicates atmospheric temperatures, shows placement of such diverse objects and phenomena as Mt. Everest, jet airliners, cumulus, nacreous and noctilucent clouds, Northern Lights, "shooting stars," various space craft. Footnotes explain each phenomenon.

Clouds and the Weather They Bring (202)

Ten major cloud formations are shown in both drawing and photograph, together with their scientific names: cirrus, cirrostratus, cirrocumulus, altostratus, altocumulus, cumulonimbus, cumulus, stratocumulus, nimbostratus, and stratus. The altitude of each is given, and its usual effect on the weather. A chart that can be used daily as a basis of class discussion as your youngsters try their hand at recognizing cloud formations and trying to predict what tomorrow's weather will be.

The Larger Orders of Insects (203)

Nine major orders are illustrated and described in this fascinating wall chart that helps your students identify the common larger insects and learn about their metamorphoses and habits. Chart gives details about the growth of the grasshopper, cricket, katydid, roach, mantid, walkingstick, mayfly, dragonfly, cicada, leaf hopper, froghopper, aphid, lacewing, fishfly, Dobsonfly, antlion, moth, butterfly, beetle, sawfly, ichneumons , wasp, bee, ant, gnat, midge, mosquito, and scale insects. Pictures show stages of metamorphosis. Text describes general habits.



Round Trip to the Moon (204)

For youngsters who've grown up in the space age, a map showing how to get to the moon is as indispensable as a map of downtown is to us oldsters. This map-diagram illustrates the rocket stages and capsules, and shows step-by-step the upcoming Project Apollo journey, from take-off to set-down to return. An especially valuable chart now that the tempo of the space race has been accelerated by tests over these past few months.

How Seeds Get Around (205)

White oak, witch hazel, burdock, lodgepole pine, coconut, red maple, pearlwort, dandelion, cherry, American lotus, tumbleweed, timothy—each of these familiar plants or trees represents a different method of seed propagation. Illustrated chart shows each type of seed, and text tells propagation method—pods that act like pop guns, "hitch-hikers," seeds released by heat, "boats," seeds that get splashed out by rain, "parachute" types, winged seeds, tumblers. Chart makes a valuable guide for walks, field trips, collections.

The Evolution of Man (206)

60 million years of life—encompassed in an impressive wall chart less than three feet in length! Diagram begins with the first primate—a small animal much like today's tree shrew—and ends at the top with man. Drawings and text show and describe such stages as Proconsul, Homo Habilis, Australopithecines, Pithecanthropus, Neanderthal Man, and such other primates as the lemur, tarsier, New and Old World monkey, great ape. An invaluable chart for making evolutionary theory vividly real and memorable.

The Ages of the Earth (207)

Chart covers 600 million years in time, illustrates more than two dozen different forms of evolutionary life, and names each major period in the earth's development. Among forms of life your pupils will become more familiar with are sponges, trilobites, echinoderms, jawless fish, crustaceans, amphibians, horsetails, early dinosaurs, pterosaurs, brontosaurus, whales, elephants, monkeys, and finally, people. Accompanying text explains differences in eras, relates each period to geographic features such as the Rocky Mountains, the Appalachians. A valuable companion chart to *The Evolution of Man*.

The Land Where We Live (208)

Instill an early understanding of and appreciation for conservation principles in your pupils with this chart that shows two identical valleys—one whose soil, water, forests, and other resources have been used to advantage, and the other a conservationist's nightmare. Chart explains how trees prevent a loss of topsoil, why crops should be rotated, how sewage is best disposed of, what keeps streams and rivers from flooding, why parks are needed, why water becomes polluted, what's wrong with up-and-down farming.

How Pollen Gets Around (209)

748-square-inch wall chart uses photographs and drawings to teach your students various methods of plant reproduction: pollination by bees, by wind, by moth and butterfly carriers, by water, and the unique case of the Yucca plant which can only be propagated by the Yucca moth. Text describes each process in detail, and the parts of a flower are shown in clear diagrams. A valuable companion chart to *How Seeds Get Around*, and a useful guide to prepare the class for walks and field trips.

The Web of Pond Life (210)

Colorful cross-section shows dozens of different forms of life that center around ponds, marshes, and other areas of quiet water. The chart emphasizes the interdependence of plant and animal life in a pond community. Described and shown are such plants and animals as the poplar, cattail, arrowhead, muskrat, spotted sandpiper, raccoon, tree swallow, water lily, green frog, diving beetle, yellow perch, water snake, crayfish, pondweed, belted kingfisher, willow, painted turtle, mallard, giant water bug, great blue heron. Special inserts show enlarged views of tiny pond insects and microscopic plants. Chart can be used as a text for educational visit to nearby pond or swamp.

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Using This Issue...

(continued from page 2T)

they interpreted each new fossil find as further proof that they were.

- *Why Did Dr. Ostrom question this idea?* As explained in the article, he did not believe that the conclusions other scientists had drawn from their studies of duck-bill fossils were necessarily the only conclusions possible. As he studied the crests, grinding teeth, and other characteristics of duck-bills, it became clear that these dinosaurs may have led quite a different life from the one assigned to them by early paleontologists.
- *Will scientists ever know for certain whether the duck-bills lived mostly on land or in the water?* Future finds of their remains, plus re-examination of past discoveries, may someday provide a more definite answer to this question. But our knowledge of how extinct animals lived can never be as complete as our knowledge of animals that can still be observed in their natural habitat.

PAGE 14 Tell-Tale Dust

Pollen analysis, or *palynology*, is a young science. Fossil pollen was first seen under a microscope over 100 years ago. However, it was not until 1916 that the first fossil pollen study was made. Palynology is now a valuable tool for the study of past plant life and climates.

Point out to your pupils that what is usually found in pollen analysis is airborne pollen, not pollen from plants that are pollinated by insects and other means. Wind-pollinated plants include many trees, shrubs, and grasses. One of the problems of interpreting the findings of pollen identification is that certain species of trees (pine, birch) produce vast amounts of pollen while others (beech, oak, elm) tend to be underrepresented in a sample because of small pollen production or insect pollination. Other trees, such as maple and ash, have pollen that decays more easily than others.

Perhaps this background information will help you show your pupils that no one tool for studying past life is perfect. Paleontologists use many tools and techniques to gather information. As the techniques are perfected and more data are gathered, man's picture of the past becomes clearer.

How Fossils Are Used

(continued from page 1T)

inferred by the presence of such fossils as the musk ox, which has been found in New York and Arkansas, and of fossil reindeer, which have been reported from France. These typical Arctic animals could not, of course, inhabit these areas today.

It should be remembered that certain fossil species may have been adapted to different living conditions from those of their modern counterparts. For this reason one should use caution in interpreting climatic conditions from the evidence of fossils. Moreover, as in the case of paleontologic correlation, it is safer to use an entire fossil assemblage than to infer climatic conditions from a single species.

Evidence of Geographic Changes

Fossils have provided us with much information about the distribution of the seas and land masses of the past. Certain animals, such as the corals, echinoderms, brachiopods, and cephalopods, have always lived in the sea. The presence of fossils of this type indicates marine deposition for the rocks containing them. By plotting the distribution of these fossiliferous marine strata, the outlines of past seas can then be determined.

The presence of fossil trees or stumps *in place* (that is, where they originally grew) would suggest a land environment, as would the bones of land animals. These remains indicate continental depositions, and the paleogeographer would, therefore, infer the presence of a land mass in an area where they are found.

Many ancient marine organisms were restricted to certain environments, and their fossils often provide some information as to the temperature, depth, and other properties of the sea water. Still other types of plant and animal remains suggest swamp or marsh conditions, during which time the land was barely above sea level. The geologist sometimes finds numerous fresh-water clams and snail shells mingled with the leaves of land plants. Fossil assemblages of this type could be typical of deposition in lakes and streams. Deltaic deposition may be indicated by the mingling of marine and land faunas and floras. The mixing occurs when a fresh-water stream enters a body of salt water.

Fossils, therefore, not only are valuable as evidence of the changing geographic patterns of our earth but also provide much information as to the type of environment in which these prehistoric organisms lived.

Records of Prehistoric Life

The study of fossil plants and animals has given us much information about the origin and evolution of organisms living today. This knowledge is possible because all modern plants and animals have descended from their more primitive ancestors which populated the earth in times past. By studying the record of the changes that organisms have undergone, the paleontologist is able to work out a family tree or evolutionary pattern for most forms of present-day life. It is thus possible to determine the relationships between different plant and animal groups and to see how life has slowly, but continually, become progressively complex.

Some forms, like the dinosaurs, ammonoids, and trilobites, have become extinct. All that is known of these animals has been learned from a study of their fossil remains. Some information has, however, been derived from a study of living animals which appear to be closely related to these extinct forms.

For example, certain living reptiles have provided information which has been helpful in the reconstruction of the body form and life habits of the dinosaurs.

A study of certain recent arthropods such as the horseshoe crab has thrown some light on the nature of the trilobites, which have been extinct since the end of the Permian period.

A comparison of living and fossil specimens is also important in the reconstruction or restoration of extinct animals. The reconstruction of the skeleton or soft parts of a dinosaur must be preceded by a careful study and comparison of the anatomical relationships of the dinosaurs with similar reptiles that are living today.

Skeletal reconstructions are, for the most part, based on sound, scientific anatomical principles. The soft parts, however, present more of a problem, because they are much less likely to leave any record of their characteristics. A small number of fossil skin impressions have been found, and some

(Continued on page 8T)

How Fossils Are Used

(continued from page 7T)

fossils, like the woolly mammoth, have been preserved in an almost perfect state. Such forms are, of course, of considerable scientific importance, as they permit a most accurate re-creation of the soft parts of the animal. Unfortunately such occurrences are exceptional, and most restorations of soft tissues and coloration are based on what might be termed "scientific imagination."

Evidence of Organic Evolution

Fossils provide one of the strongest lines of evidence to support the theory of *organic evolution*. This theory states that the more advanced forms of modern life have evolved from simpler and more primitive ancestral forms of the geologic past. The transformation has been gradual and has been brought about by such factors as heredity, changes in environment, the struggle for existence, and adaptability of the species.

The older rocks contain the remains of organisms which differ considerably from living forms, and younger rocks contain fossils that appear to be more closely related to the plants and animals that are living today. This succession of fossils clearly indicates that life has slowly evolved from a few simple ancestors to the many different types of organisms that inhabit the earth today.

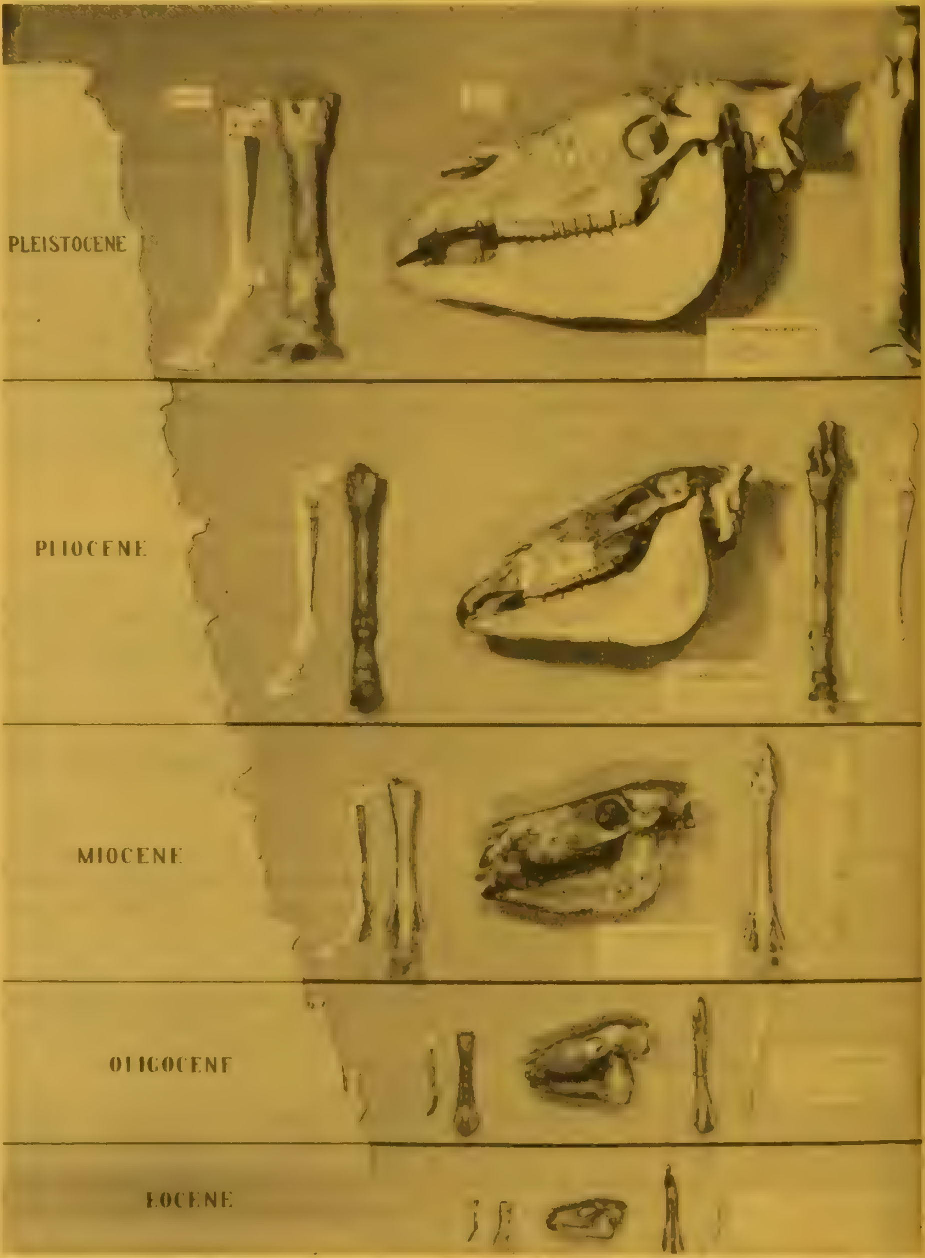
One of the best-known records of evolutionary change is found in the series of fossil horses from Cenozoic rocks (*see photo*). This record begins with the small, primitive, four-toed *Hyracotherium* (*Eohippus*) of early Eocene time, and continues for some 60 million years through the Oligocene, Miocene, Pliocene, and Pleistocene, and up to the present time. This series culminates in our modern horse, *Equus*, with its relatively large size and one-toed hoofs. [For a more detailed account of the evolution of horses, see *Horses*, by George Gaylord Simpson, The Natural History Library, Anchor Books, Doubleday & Company, Inc., Garden City, N.Y., $1.75.]

The fossil record contains many such examples of evolutionary documentation, and it is little wonder that paleontology has been considered one of the foundation stones of the theory of organic evolution.

Economic Tools

Since many of our more important resources are associated with sedimentary rocks, fossils, when present, may be of help in locating ores, coal, oil, and gas. For example, mining geologists use fossils to date the strata above and below the rocks that contain valuable minerals. In addition, fossiliferous rocks may also provide clues as to where these ore-bearing rocks may be found. Coal deposits, which are commonly associated with fossil plants, have been found in much the same way. Valuable deposits of radioactive minerals have been discovered in sedimentary rocks, and in some of these strata the ore concentrations are found closely associated with fossils.

The economic utilization of fossils has become increasingly widespread with the expansion of the petroleum industry. A great many geologists and paleontologists are actively engaged in the search for geologic formations that may contain profitable accumulations of oil and gas. A knowledge of fossils is basic in the search for these oil-bearing rocks ■



THE AMERICAN MUSEUM OF NATURAL HISTORY

These fossil feet and skulls of horse-like animals that lived in the past 60 million years show how Eohippus, about the size of a small dog, evolved into the horse of today. In this display at The American Museum of Natural History, you can see the changes in size and shape of the bones from animals that lived in succeeding periods.

nature and science

TEACHER'S EDITION

VOL. 3 NO. 4 / NOVEMBER 1, 1965 / SECTION 1 OF TWO SECTIONS

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"I Never See an Uninteresting Landscape"

by Paul B. Sears

How to make conservation a part of science and other subjects by using your immediate surroundings as teaching examples.

■ To me, as to many others, the greatest eye-opener in my education has been the study of the earth and its inhabitants. Thanks to what I know of geology and biology, I never see an uninteresting landscape, for this kind of training enables one to see, not merely what is present, but what is happening.

Often the view is refreshing and beautiful, showing what is possible. Many times it is depressing, reminding the observer of what must be done and calling him to action. In any event, the ability to see and understand is necessary to the full enjoyment of life and equally necessary today to good and responsible citizenship.

No special course on natural resources and their conservation is needed if, whatever the science course, it draws upon the immediate surroundings for its examples. This has the double advantage of producing a lively course and giving the pupils some kind of information they will need for future enjoyment and responsible citizenship. At the same time it will help train them to use their senses in observing their surroundings. Too many of us go through life half-blind despite good vision.

Examples For Teaching Science

For earth science, whatever it is called, and biology the chances for this kind of teaching are clearest. In geology or geography, hills or the tops of high buildings give a chance to study topography and drainage patterns, and to observe how these can be related to present land use or misuse.

The frequency of floods, for example, can be learned from local records and the extent of damage from ill-advised location of housing and industry in the flood plain can be observed. Students can easily see for themselves how well the pattern of highways and recreation areas fits into the nature of the landscape and the needs of their community.

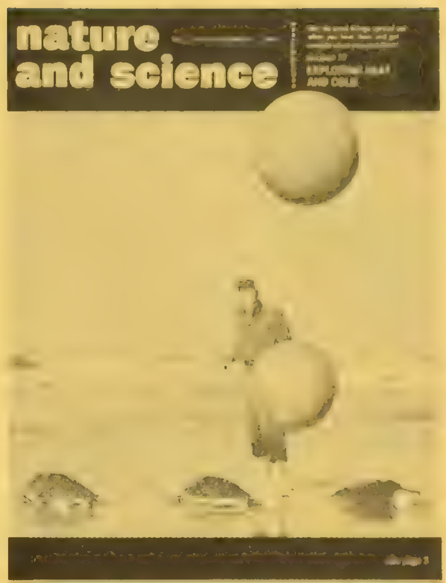
Man-Made Changes Need Attention

We are part of the living landscape. So are all of the renewable resources —air, water, soil, plants, and animals. For most of his million years or so, man has fitted into this picture without too greatly disturbing its delicate balance. Only recently have we developed the knowledge, the numbers, and the power to disrupt the system which has made our existence possible. Ten years brings more change than centuries once did, and the process moves even faster. What really needs attention is man-made change in the past few generations.

Court house records and county histories may seem strange sources of biological knowledge. Yet the records of early land surveys and pioneer experiences can often be used to reconstruct conditions as they were at the time a county was settled by the white man. Forests, prairies, swamps and streams, even springs can be located

(Continued on page 3T)

Dr. Sears is a botanist and ecologist who has served as president of the American Association for the Advancement of Science and as chairman of the National Audubon Society. This article was extracted from his address at the National Science Teachers Association 1965 convention.



IN THIS ISSUE

(For classroom use of articles preceded by ●, see pages 2T and 3T.)

The Voyages of the Green Turtle
A scientist tells how these sea animals are traced to find out where they go on their long migrations and how they find their way.

What Holds It Up?
Your pupils can make a leaning tower of books and find out how a cantilever works.

● **Winter Is on the Way . . .**
A gallery of animals and plants, showing how they are adapted for survival in winter, can start your pupils searching for other examples.

● **Exploring Heat and Cold–Part 1**
Making two kinds of thermometers will show your pupils how temperature is measured and introduce them to the phenomena of heat and cold.

● **There's More to Color Than Meets the Eye**
Projects and investigations in separating white light into colors of the spectrum, adding colors and subtracting them, introduce your pupils to the wave theory of light.

How It Works—Photographic Film
Black-and-white and color film are explained in this article.

IN THE NEXT ISSUE

How a dog owner can influence his pet's "personality" is revealed in a 13-year study of dog behavior . . . The jobs our satellites are doing . . . What happens to matter at supercool temperatures? . . . How to ripen green tomatoes with bananas . . . Where did the glassy stones called "tektites" come from?

USING THIS ISSUE OF NATURE AND SCIENCE IN YOUR CLASSROOM

8 Winter Adaptations

Each kind of plant and animal is adapted to survive in its environment. This WALL CHART shows examples of this concept, including some that are found only in the temperate regions of the Northern Hemisphere. You can find other examples of seasonal adaptations in your area, even if you live in southern United States. Point out to your pupils that the dry season in southwestern deserts is like a long winter. Some small desert mammals go into deep summer sleep (estivation) that is like the winter sleep (hibernation) of animals in the north.

Topics for Class Discussion

- *What is migration? What kinds of animals migrate?* Migration is a periodic movement to and from an area. It is sometimes confused with *emigration,* which is a one-way movement. We usually think of migrations as long journeys over thousands of miles, but many are shorter. Toads, for example, may travel only a few hundred yards from the ponds where they return to breed each spring.

There are also vertical migrations, that is, up and down travels of mountain animals as the seasons change, and day-night movements of fish and other ocean life. Your pupils may also name these other migratory animals: whales, seals, eels, salmon, monarch butterflies, and green turtles *(see "The Voyages of the Green Turtle," page 2).* Some of these migrations, of course, are prompted by reproductive urges, not seasonal changes.

- *What other animals besides snowshoe hares change to white coats in the wintertime?* The best known examples are the weasels. Others are the arctic hare and the ptarmigan (a grouse-like bird). Some other arctic animals, such as polar bears and snowy owls, are white all year round.

- *What animals store food for the wintertime?* Besides pikas, many other rodents store food. They include chipmunks, squirrels, and beavers. Although chipmunks hibernate, they sometimes awake to feed. Thus they do not store as much fat on their bodies as other hibernators.

10 Thermometer

This article is the first of a series of three articles exploring heat and cold. By making and calibrating a copper-wire or air thermometer, your pupils can see how the wire or air expands when heated and contracts when cooled. The explanation of these phenomena introduces the concept that heat is a form of energy—kinetic energy, or the energy of motion of atoms and molecules making up any substance.

The next two articles will carry this concept further and explain what happens when most of the kinetic energy of atoms and molecules is removed to produce extremely low temperatures, or when energy is added to them to produce extremely high temperatures.

Suggestions for Classroom Use

- You can demonstrate the unreliability of the human sense of touch in detecting heat and cold by having a pupil dip one hand into a container of hot water (about 105°F) and the other hand in a container of ice water, then dip both hands into a container of water at room temperature. The room-temperature water feels warm to the hand that was in ice water and cool to the hand that was in hot water.

- Temperature, which should not be confused with heat, is measured with a thermometer, as distance can be measured with a ruler. And as there are different units for measuring distance, there are also different units for measuring temperature. Point out that units of measure are arbitrary and man-made *(see N&S, Vol. 1, No. 3, page 10).*

Your pupils could number the marks on their thermometer scales, beginning with 0 at the bottom, 1, 2, 3, and so on, and call them, say, "degrees Q" if the distance between marks is one-quarter of an inch, or "degrees S" if the distance is one-sixteenth of an inch. Would the room temperature be the same in "degrees Q" and "degrees S"? If every person had his own private temperature scale, would the temperature readings printed in a newspaper, for example, mean anything to a reader? How could they be made meaningful?

These questions open the door to discussion of the two standard temperature scales. In the United States, nearly all of our household thermometers are calibrated in degrees Fahrenheit (after the German physicist who devised this scale). On the Fahrenheit scale ice melts at 32°, and water boils at 212°. There are 180 Fahrenheit degrees between the melting point of ice and the boiling point of water.

The other temperature scale, which is used in nearly all other countries of the world and in laboratories, is called the centigrade scale, because it has 100 degrees between the melting point of ice (0°) and the boiling point (100°) of water. (This is sometimes called the Celsius scale, after the Swedish astronomer who devised it.)

- A good exercise in arithmetic for your pupils would be to try to work out a way to convert temperature readings from degrees F to degrees C and vice versa.

You might begin by drawing a vertical line on the chalkboard and marking a point near the bottom 32°F on one side of the line and 0°C on the other side. Mark a point near the top of the vertical line 212°F and 100°C. By subtracting 32 from 212, your pupils can see that 180 Fahrenheit degrees equal 100 centigrade degrees, and by dividing, that 1 degree F equals 5/9 of a degree C. Remember, though, that a temperature on the Fahrenheit scale includes 32 degrees (0° to 32°) that do not show on your chalkboard scale. So, to convert a Fahrenheit tem-

(Continued on page 3T)

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Why do most things spread out when you heat them and get smaller when you cool them?

see page 10

EXPLORING HEAT AND COLD

Radio-carrying balloons for sea-going turtles

see page 3

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A SCIENCE MYSTERY

the VOYAGE O GREEN TURTL

After laying their eggs on the beaches, these huge turtles vanish into the oceans. Where do they go? How do they find their way back after two or three years?

■ A hundred million years ago, when dinosaurs were st around and birds were just beginning to cruise the skie there were giant turtles in the oceans much like the s turtles of today. Since those days the birds have changed great deal. They have evolved a bigger brain and, with the ability to fly skillfully and even to make long distan migrations.

Meanwhile, the sea turtles changed little in form ar habits. But in the quiet fashion of turtles, they began doir one thing that was just as wonderful, and perhaps eve bit as complicated, as what the birds were doing. Some them began to make regular journeys of many hundred of miles between their feeding grounds and their nestin beaches. They learned to navigate the open oceans witho getting lost, with nothing but their senses to guide them

Of course no one knows exactly how many millions years ago the turtles began making their high-seas voyage In fact, until a few years ago, almost nothing was know about the great distances they swim or how accuratel they can navigate. The first inkling came from caref observations of the behavior of the green turtle.

The green turtle is a good-natured animal that grows be a little longer and a little wider than a folded chair. weighs from 200 to 600 pounds. The turtle is not gree it is olive or brownish in color. The name comes from th color of the fat that lines the inside of the turtle's shell.

Green turtles are found in all the tropical oceans of th world, and there are nesting beaches in Australia, South ern Asia, Africa, Central and South America, and on man oceanic islands. Several hundred years ago these turtl lived and nested in large numbers along the coast of south

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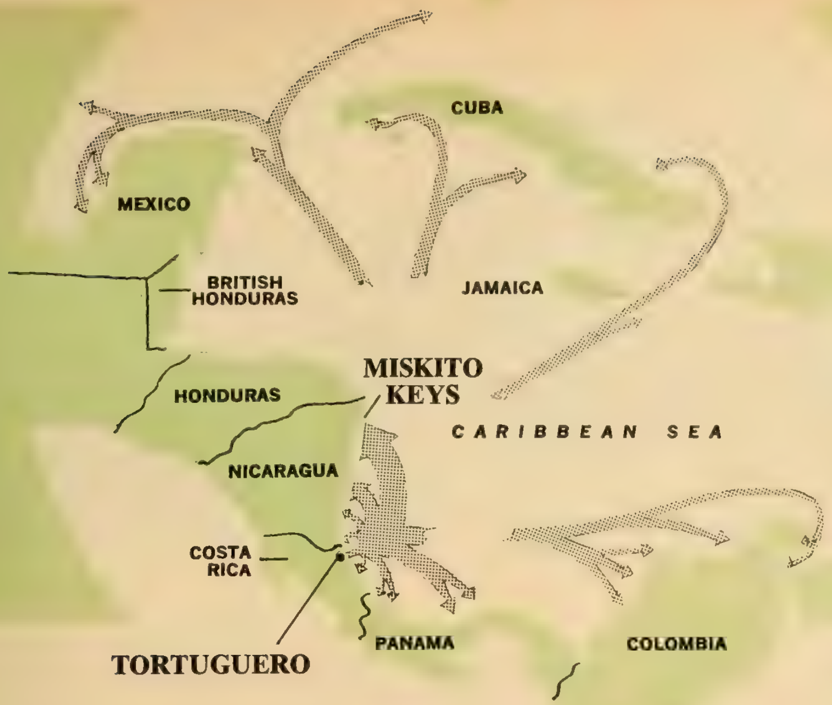


These arrows point to places where turtles that were tagged at Tortuguero have been recovered. The exact routes they followed are not known.

y Archie Carr

rn Florida. Now they are very scarce in Florida, and hard-y any nesting goes on there.

he Place of the Turtles

There is one beach in the western Caribbean Sea where everal thousand female green turtles still come ashore to ay their eggs during July, August, and September. The lace is Tortuguero, which in Spanish means "place of e turtles" (*see map*). Here, at night, the female turtles rawl up out of the surf onto the fine dark sand. They push eir snouts briefly into the wet sand, perhaps to prove by mell or feel that they have reached the right place. Then ey go up the beach above the reach of the highest tides. here, with their back flippers, they dig a neat, deep hole ig enough to hold about 100 leathery white eggs. Each gg is the size and shape of a ping pong ball. This is the nly time that a female Caribbean green turtle ever leaves he water—the males never do. It is the only good opporunity a zoologist has to count, measure, and mark the rtles and to study their habits.

It was here at Tortuguero that we were first able to rove the unusual migratory habits of the green turtle. he local fishermen had known about the migrations for ears. In the nesting season (from July to September) here were plenty of turtles in Costa Rican waters. But the shermen noticed that the turtles all seemed to disappear rom October to June. Where did they all go?

When we began to study the Costa Rican turtles, we earched the whole coast of Central America. We discovred that 300 miles to the north, in the Miskito Keys (*see ap*) the numbers of green turtles increased during the period from October to June—the same period when they disappeared at Tortuguero. Among the Miskito Keys they spread out over the dense underwater pastures of turtle grass, grazing during the daytime and passing the night among patches of rocks on the bottom. Could these be "our" Tortuguero turtles? How could we be sure?

Every summer since 1954 a team of scientists from the University of Florida, at Gainesville, has gone down to Tortuguero. We tagged the turtles when they came up to nest on the beach. A small metal tag is attached to one of the turtle's front flippers. Each tag is numbered and en-

(Continued on the next page)

ABOUT THE COVER

To find out where the green turtles go after they leave the beach at Tortuguero, Dr. Carr and his fellow scientists are now tracking them by radio. The cover of this issue shows Dr. Carr launching balloons that are filled with helium so they will float in the air. Each balloon carries a tiny radio transmitter and is held by a line 15 to 30 feet long to a ball of plastic foam that floats in the water. A line about 15 feet long runs from the plastic float to the turtle's shell. Towing the light plastic float does not seem to slow up the turtles, and signals from the radios enable the scientists to trace the path of the turtles long after they have swum out of sight. Recently, the scientists began using blimp-shaped balloons with tail fins. These "blimps" hold the radio transmitters high above the water in a wind that would push a round balloon down close to the water.

The green turtle's flippers can pull its heavy body through water with ease. But they are not well shaped for pushing the animal through wet sand. The turtle also has to lift its body from the ground to let its lungs expand and take in air.

graved with an offer of a reward if returned to the University of Florida. By the end of 1964 we had tagged more than 3,000 turtles. So far, 130 tags have been returned to us by turtle fishermen.

As we guessed, most of the marked turtles that were recovered were caught in the Miskito Keys. But many had gone much farther, some as far as 1,000 miles (*see map on page 3*). This told us that the female turtles we were tagging at Tortuguero often travel long distances away from the nesting beach. It did not tell us whether they were traveling in a definite direction, or whether they ever came back to Tortuguero again. But as the tags kept coming in and we thought about them for a while, we were able to figure out more about what the green turtles were doing.

The Turtles' Return

Two years after the first turtles were tagged we began to find tagged turtles coming back to nest at Tortuguero. The third year even more tagged turtles came. It seems that green turtles return to nest at Tortuguero at intervals of either two or three years—never two years in a row. None of the marked turtles has ever been reported nesting anywhere besides Tortuguero. Also, no marked turtle has ever been caught near Tortuguero after the nesting season was over.

Putting all these facts together reveals part of the surprising life of the Caribbean green turtle. It appears that every summer turtles come from all over the western Caribbean to nest at Tortuguero. After nesting there, they return to their far-away feeding grounds and stay there until their next breeding season two or three years later. The Costa Ricans who fish in Tortuguero waters during the nesting season catch as many male turtles as females. This means that the males travel with the females from the feeding grounds to Tortuguero.

The evidence for all this is what both scientists and lawyers would call "circumstantial." That is to say, our tagging program is a very roundabout way of finding out what green turtles do. No one has actually followed a green turtle on its migration. Also the success of the tagging project depends on the Central and South American turtle fishermen. We can only wait and hope that when they catch our turtles they send the tags back promptly, and don't use them as bracelet charms as some of the coastal Indians of Panama were reported to be doing.

Even so, we do know that green turtles migrate over remarkably long distances and regularly return to special places. The next question is, how do they guide themselves during these journeys?

Do the green turtles smell their way from the Miskito Keys to Tortuguero? Do they use the positions of the stars to chart their course? Or is there some simpler way for them to get back and forth between their feeding and nesting places?

There is an easy way for the green turtles to find Tortuguero. All a turtle would have to do is to start swimming from the Miskito Keys and keep the coast on the right side. Sooner or later she would come to Tortuguro (*see map on page 3*). She also would have to be able to recognize the right place to stop.

Then, after she finished nesting, the turtle would simply start swimming with the coast on her left side and keep going for a couple of hundred miles till she got back to her island again. This sort of guidance is called *piloting* or *landmark* navigation.

To find out whether the green turtle is capable of some more complicated navigation we had to study the habits of a different group of green turtles. We chose a colony that nests on Ascension Island, a tiny speck of land in the South Atlantic Ocean midway between Brazil and Africa (*see map*). The South Equatorial Current sweeps past Ascension in a westerly direction at a steady three miles per hour. The water around the island is far too deep for turtle grass to grow, so the turtles nesting there must have to go somewhere else for food. But where?

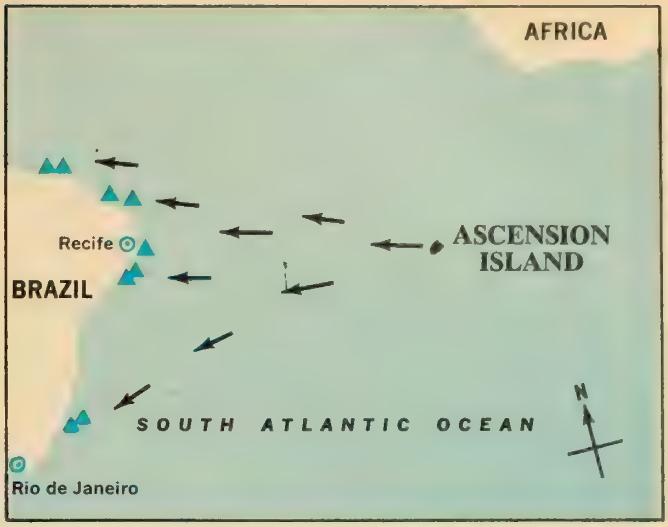
Tagging Turtles on Ascension Island

In 1960 Dr. Harold Hirth, who was then a graduate student at the University of Florida, spent several months on Ascension. He tagged 206 of the turtles on six different beaches. From these the first part of our answer soon came in. During the following months nine tags were sent back to us. In each case, the turtle had been captured on the coast of Brazil, at least 1,200 miles from Ascension. And now that several years have passed, some of the tagged turtles are coming back to the island to nest again, each of them on the same beach where she was originally tagged.

It now seems fairly certain that the green turtles that feed along the Brazilian coast swim more than 1,000 miles, against the current, to lay their eggs. As little turtles that hatched on Ascension Island, they are probably carried straight to Brazil by the same current. But how do the migrating females ever find their way back to the island?

These turtles could not possibly be using landmarks in their travels through the open sea. There is no coastline to follow, and the water is too deep to allow the turtles to see any landmarks on the ocean floor. Some people have suggested that the turtles may use the current to guide themselves. However, there is no way of knowing you are in a current unless a fixed landmark is in sight. So the Ascension-bound turtles can't possibly know they are in the Equatorial Current, any more than you are aware of the rotation of the Earth—even though you are moving many hundreds of miles an hour.

The green turtles may find their way by the sun or the stars or both—something like the way certain birds do. However, no one is sure whether a turtle can make the accurate measurements needed in sun or star navigation.



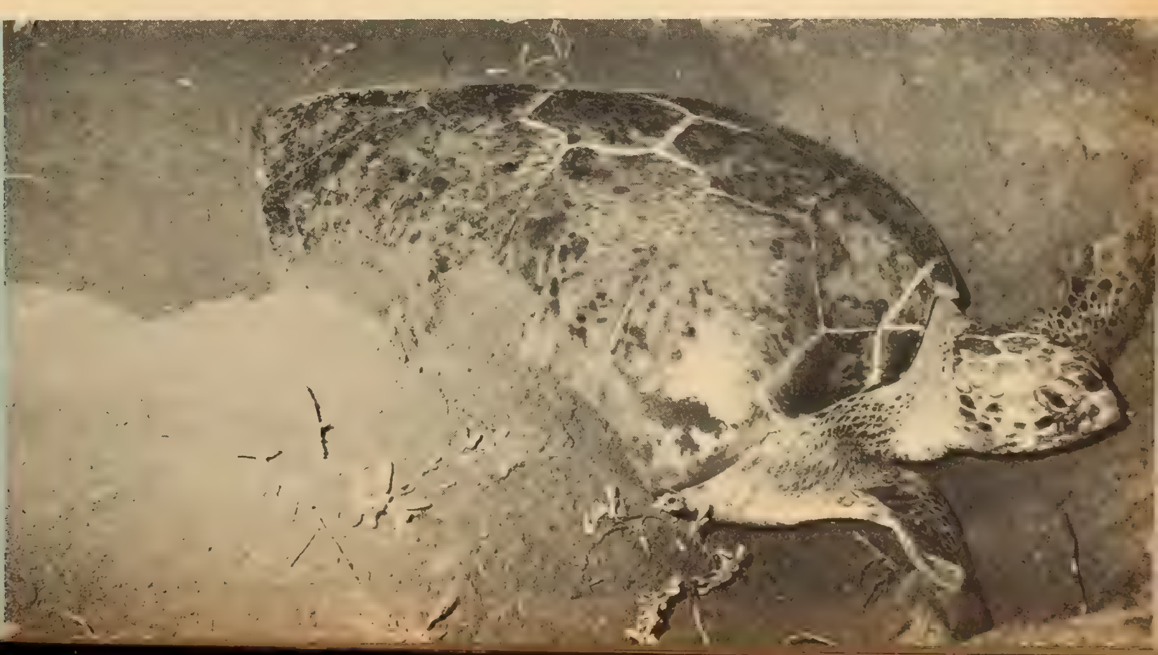
The triangles on the left side of this map show where nine green turtles were captured on the coast of Brazil. They had been tagged on Ascension Island, over 1,000 miles away. From Brazil, the turtles return to lay their eggs on Ascension. Exactly how they find their way is still a mystery. The arrows on the map show the directions of ocean currents.

For example, a sailor finding his position by the sun needs a very accurate sextant for measuring the sun's position. He also needs a very accurate chronometer for telling time. Perhaps a turtle's eyes are good enough to measure angles—like a sextant. Perhaps a turtle's internal "clock" —the built-in time sense that many animals are known to have—is good enough to give some feeling for the passing moments and for the time of day. But are these senses accurate enough to take a turtle 1,400 miles through rough, deep water, against the changing directions of a current, directly to an island only six miles wide?

Some other ways of turtle navigation have been sug-

(Continued on the next page)

A female green turtle digs a pit in the wet sand. She will rest there while digging a smaller hole and laying her eggs in it. Only the females come ashore at all, and then only to lay eggs.



gested—for example, that green turtles can "smell" Ascension while they are still in Brazil and follow their noses to the island. But this idea and others are hard to test, and seem less likely than the star-and-sun navigation theory.

Perhaps, instead of depending on one method of guiding their journeys, the turtles use a combination of a number of different ways. They may find their way by a method not yet even thought of by biologists.

To get more information about the turtles' travels, we are putting little radio transmitters on them (*see "About the Cover," page 3*). Then we can track them by listening to the radio signals. We are also studying green turtles in laboratories to find out how well they can see, and what sorts of odors or tastes they can detect in the water. From the experiments we may someday solve the mystery of their long ocean journeys.

In this article it has not been possible to tell much, really, about the green turtle. It seems too bad for instance, not to tell how the hatchling turtles work together to dig themselves out of their nest in the sand. Or how they are able to find the ocean from a nest far back on the upper beach. Still, maybe enough has been said so that the next time you pass by a baby turtle in a pet store, you will think of its remarkable relatives who were navigating the oceans of the world long before there were any men to wonder about such things ■

a long-time turtle follower

The author's son Chuck (left) helps Dr. Hirth inflate a radio-carrying balloon as Dr. Carr attaches a line and plastic float to a turtle *(see "About the Cover," page 3).*

■ Ever since Archie Carr was old enough to walk, he has been fascinated by animals—especially turtles. His mother and father encouraged him to follow this interest both in and out of school. In college he studied *zoology*—the science of animals and animal life—and he earned his doctor's degree by studying the reptiles of Florida. Dr. Carr is now a Professor of Zoology at the University of Florida, in Gainesville.

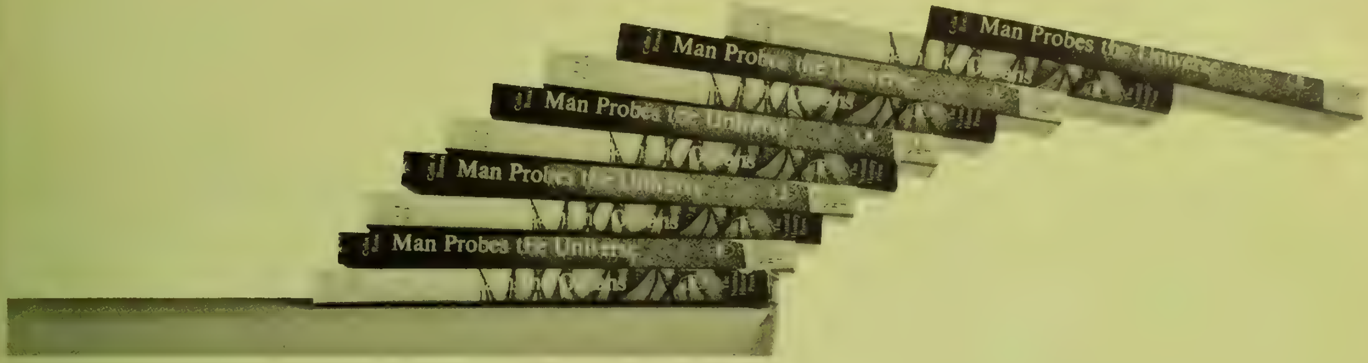
When Dr. Carr wrote *Handbook of Turtles* [(Comstock) Cornell, Ithaca, N.Y., 1952, $7.50], he was surprised at how little was known about sea turtles. He has been trying ever since to fill in some of the gaps.

Dr. Carr's chasing around after sea turtles has involved his family in a lot of travel, including four years of living in Honduras and two years in Costa Rica. His wife, Marjorie; daughter Mimi, 22; and sons Chuck, 20; Stephen, 18; Tom, 17; and David, 13, are all turtle-minded, and they have helped him a great deal (see *photo*).

Most of the sea turtle research is done in Costa Rica. A turtle hatchery is operated there by the Caribbean Conservation Corporation, which was organized to restore the green turtle to the Caribbean Sea. And the turtle-tagging camp at Tortuguero has been manned by students from the University of Florida each summer since 1954.

Dr. Carr visited Tortuguero twice last summer, then returned in September to take part in this year's Operation Green Turtle. In this operation, a U.S. Navy airplane picks up 20,000 of the little green turtles raised at the hatchery and distributes them among 12 places in the Caribbean where green turtle nesting colonies once existed but have since been destroyed by man ■

WHAT HOLDS IT UP?



■ Why doesn't the "leaning tower" of books shown in the photo above topple over? Are the books stuck together in some way? Or is it trick photography?

There is no trick to it. By making a leaning tower of books like the one shown here, you can find out what keeps the books from toppling over.

Find 8 to 12 books, all about the same size and shape. (You may find that thin books are easier to work with than thick ones.) Stack the books on top of each other on a table so the books form a straight tower. Now pull the stack toward you until the front edge of the bottom book lines up with edge of the table.

Next slide the top book out about halfway over the edge of the book below it. Find where it just balances and then slide it back just a little bit. Next move the top two books together until they just balance on the third book. Then move them back just a bit.

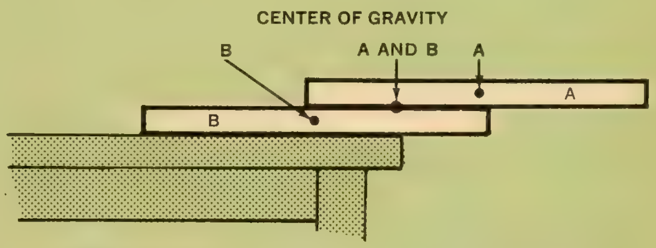
Keep moving the books this way, taking one more book along each time until the whole stack looks like the tower in the photograph. As a final step, slide all the books together until they just balance on the edge of the table, then move them back a little bit.

Notice that the top book is way out beyond the edge of the table. What keeps it from being pulled to the floor by the earth's gravity?

The earth's gravity *is* pulling these books downward, and that is why they do *not* topple over. Gravity pulls on an object as if the weight of the object were all at one point, which is called the *center of gravity* of the object. You can see how this works by balancing a book on the tip of your finger. As long as your finger is between the book's center of gravity and the earth's center of gravity, the upward push of your finger will keep the book balanced and keep it from falling to the floor.

The center of gravity of the top book of your tower must be resting on the second book or the top book will be pulled to the floor. When you move the top two books at once, they become a "single object" with a single center of gravity somewhere between the center of gravity of each book (*see diagram*). As you inch more books forward, the center of gravity of the tower changes. But if the table is between the center of gravity of the stack and the center of the earth, the tower will not topple.

How many books do you think you can stack this way? Will the shape of your tower change if you use thicker books? Can you think of some way to make the tower stick out even farther from the edge of the table by changing its center of gravity? Hint: Try using weights.



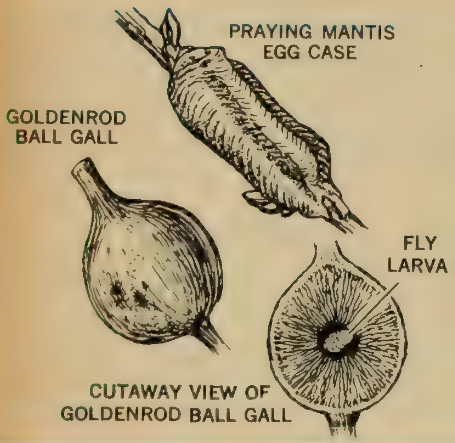
The center of gravity of books A and B together is half way between book A's center of gravity and book B's.

The shape of your leaning tower of books is called a *cantilever*. You have probably seen a bridge over a river that was made by building a cantilever out from each side and joining them in the middle. Can you think of other ways that a cantilever is used–in building balconies, for example? ■

This article was adapted from the book The Crazy Cantilever and Other Science Experiments, *by Dr. Robert R. Kadesch, published by Harper & Row. Copyright © 1961 by Robert R. Kadesch. Printed by permission of the publishers.*

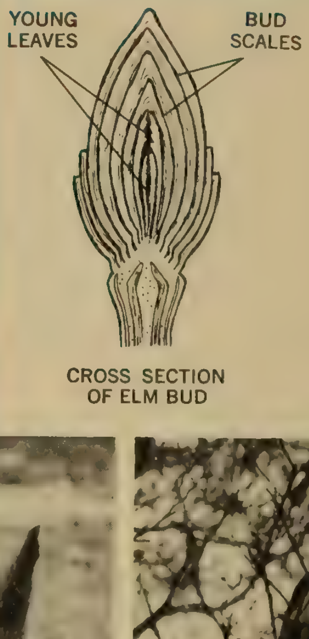
MIGRATION is not just for the birds. Some mammals, including caribou and some kinds of bats, also migrate. In summer, these barren-ground caribou feed and raise their young in northern Canada and Alaska. Then they travel south, as far as 800 miles to forests where they are somewhat protected from the arctic winter. Can you think of other kinds of animals that migrate in the fall and spring? What about insects? Fishes? ⟶

Winter is on the way...



CUTAWAY VIEW OF GOLDENROD BALL GALL

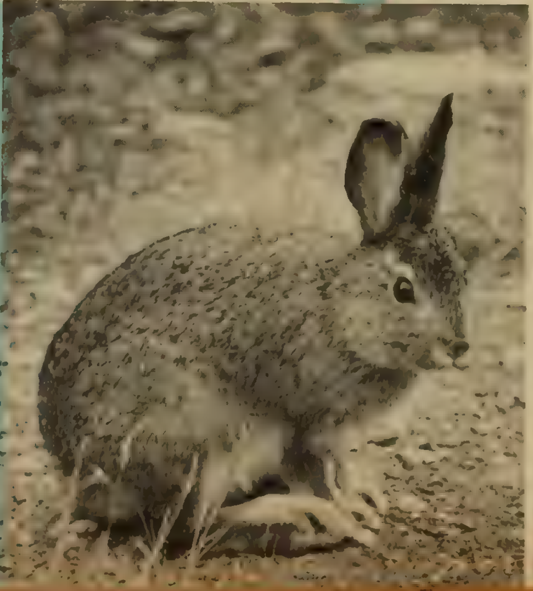
ONE YEAR OR LESS is all that some plants and animals have to live. The first frost marks the death of many adult insects and some kinds of plants. The plants have left seeds, however, and insects or their eggs, larvae, or pupae are hidden under bark, leaves, soil, and in other protected places. You will find many kinds of insects in various stages of development inside plant galls *(see diagram).*

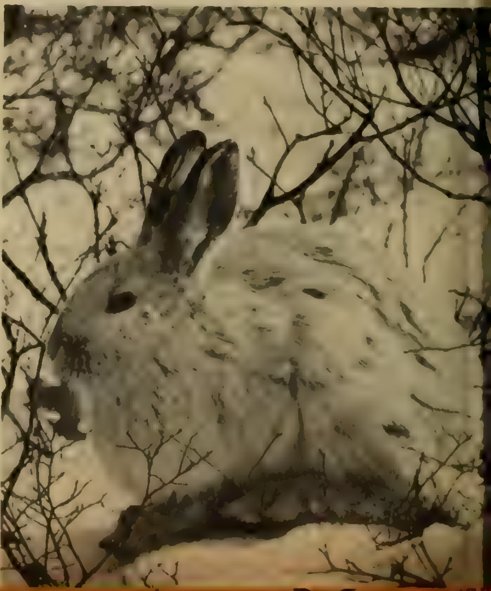


CROSS SECTION OF ELM BUD

MANY TREES seem to be dead in the winter. In a way, they are hibernating like certain animals. If you cut down through the bud on the end of a twig *(see diagram)*, you will find the young leaves that will bloom in the spring. They are protected from drying out by layers of tough bud scales.

NOW YOU SEE IT, now you don't. In summer, the snowshoe hare is a gray-brown color (left). As winter nears, a new coat of white-tipped hairs gradually covers the animal. Soon the hare blends into the snowy background (right). Snowshoe hares also have large, hairy feet—"snowshoes"—that enable them to move easily over snow. Can you think of other animals whose fur or feathers change to white in the wintertime? ⟶



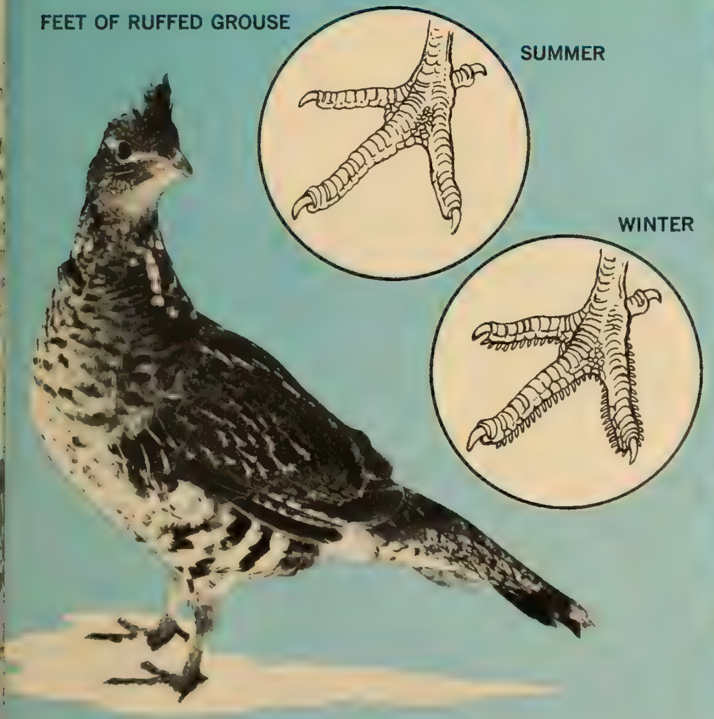


HIBERNATION is a death-like sleep. An animal's breathing, heart beat, and other body processes slow down until the animal is barely alive. In this way, it survives the winter by using very little food energy. Hibernators include chipmunks (right), woodchucks, and some bats and mice. Some other mammals, such as bears and skunks, are not very active during the winter, but they do not hibernate. ⟶

■ If you had been living in North America many millions of years ago, you would have found the weather warm and damp all year around. There were no winters as we know them. Then the climate began to change. To survive, the kinds of plants and animals living then had to be able to live through cold seasons.

As millions of years went by, certain kinds of plants and animals lived through the winter better than others. Other kinds of organisms didn't do as well, and, over the years, they died out. Today, the plants and animals you find in the northern part of the United States all have ways of behavior or characteristics, such as body shapes or protective coats, that help them to survive the winter season.

The photos and drawings in this chart show some of the ways in which different kinds of plants and animals are adapted to live through the winter. Look around this fall and winter and see if you can find other ways in which life changes to survive the harsh world of winter ■



FEET THAT GROW into a kind of "snowshoe" help the ruffed grouse walk on snow. These birds live in forests of southern Canada and northern United States. In the fall, a comblike fringe grows on the edges of their toes *(see diagram)*. This fringe increases the surface of the birds' feet two or three times, enabling them to walk on snow without sinking.

MAKING HAY is the way the pika prepares for winter. These rodents, about the size of a chipmunk, live on the rocky slopes of western mountains. Through summer, pikas cut stems of grass and put them in piles to dry. The dried "hay" is then stored among rocks for winter food. What other animals store food for the winter?

exploring heat and cold

PART ONE:

HOW TO MAKE A THERMOMETER

BY ROY A. GALLANT

Here are two kinds of thermometers that you can make with easy-to-get materials and use to investigate heat and cold.

■ Can you guess what the temperature is where you are right now? As "human thermometers" we are not very good. We do well if we can guess the temperature of the air, or of our bath water, within five degrees.

Non-living things—liquids, gases, solids—make much more reliable thermometers. That is, they are changed by heat or cold in such a way that we can use them as yard sticks of a sort. Your schoolroom thermometer, or the one in your living room or outside your kitchen window at home, is filled either with mercury or with alcohol. If you have a dial-face thermometer, the part that changes with the temperature is made of solid metal rather than a liquid. Do you think that a thermometer would work if it were filled with water? When wouldn't it?

Making a Copper-Wire Thermometer

The diagram on the next page shows you how to make a solid thermometer. You will need a few scraps of wood, a piece of copper wire, and a thin coat hanger. Be sure that the copper wire is very nearly 12½ inches long, as shown. Also, the hole that the bent end of the coat hanger slips into should be at least an inch deep, and it should be large enough so that the coat hanger rides in it freely. If it fits tightly, or binds, the coat hanger will stick in one position and the thermometer will not work.

After you have built the thermometer, make a scale on a piece of file card or stiff paper *(see diagram)*. The closer you space the markings, the more accurate your readings will be. The first scale you make could have marks one-quarter inch apart. After you have used the thermometer a few times you might want to make another scale, one that will enable you to make smaller readings. You might make the marks 1/16 inch apart. If you do this, you should cut out and tape a cardboard pointer to the end of the coat hanger *(see diagram)*.

To use your thermometer, you might begin by writing the letter *R* beside the mark the pointer indicates at room temperature. After you have done this, hold an ice cube gently against the top of the copper wire.

As you touch the ice to the copper wire, which way does the pointer move? How many marks does it move? Write the letter *I* (for ice) beside the mark where the pointer comes to rest.

Next ask some adult to hold a lighted match against the copper wire, so that the wire is in the flame. Which way does the pointer move this time? Why did the flame make it move? Write the letter *F* (for flame) beside the mark where the pointer comes to rest when the wire is hottest.

If you have an extension cord with a light socket, hold the lighted electric bulb as close as you can to the wire without letting it touch the wire. Is your thermometer sensitive enough to react to the light bulb? You could also place the thermometer on or near the oven when someone is cooking. If it is winter time when you build the thermometer, you can leave it out of doors for several minutes and then read it. What other ways can you think of for testing the sensitivity of your thermometer?

Temperature and Atoms

When you touch an ice cube to the copper wire, does the wire become longer or shorter? What happens to the wire when it is heated? In one way, the copper wire is like other things around us. It is made of very small bits of matter called *atoms*. The water you drink, the air you breathe, this magazine—all are made of atoms. When atoms are joined together, they form *molecules*. For example, when two atoms of hydrogen and one atom of oxygen stick together, they form a molecule of water. If you could keep dividing a drop of water in two until you had the smallest possible drops of water, each drop would be a single molecule. To make such a "drop" any smaller would mean breaking the molecule apart into its individual atoms. They would then no longer be water.

Atoms and molecules are moving all the time. The atoms in a piece of metal are packed tightly together and jiggle in place. The molecules making up a liquid, say water, are packed loosely—so loosely that they are free to move around, bumping, and slipping and sliding over each other. This is why liquids flow easily and solids do not. In a gas, such as the air, the atoms and molecules are much more loosely arranged than they are in a liquid. They are free to dart this way and that, bumping into one another and flying off in new directions each time they bump.

When we make something cold, all we are doing is causing the object's atoms and molecules to slow down—no matter whether the atoms and molecules are a gas, liquid, or solid. What we do is take away from the atoms some of their energy of motion, called *kinetic energy*. When we heat something, we add energy, causing the atoms and molecules to speed up. The speeding up makes the colliding atoms and molecules fly farther apart than before. We then say that the substance has *expanded,* or spread out. Cooling an object takes energy away from it and slows down the atoms and molecules. Because they are moving slower, the atoms and molecules do not bounce as far apart as before. We then say that the substance has *contracted,* or become more tightly packed. In general, this is what gases, liquids, or solids do when they are heated or cooled.

How To Make an Air Thermometer

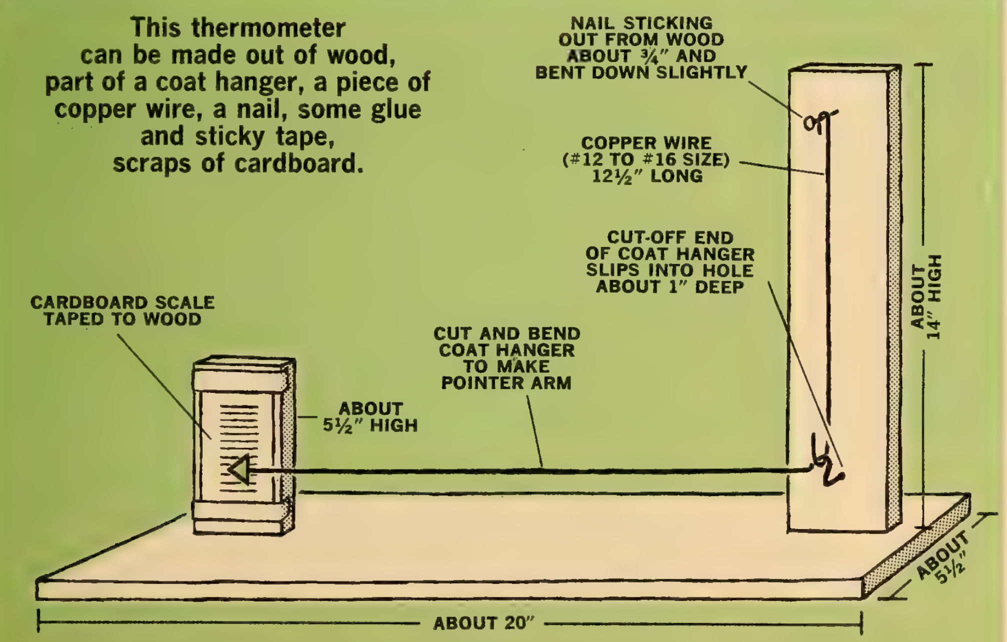
An air thermometer is a much more accurate instrument than the copper-wire thermometer. To make one, you will need one wide-mouth glass jar, one glass bottle about the size of a baby food jar (or a bit smaller), and a glass tube or clear plastic drinking straw. The bottle should have a screw-on cap.

Punch a hole in the cap of the bottle so the straw fits into it snugly. Screw the cap on tight, then drip wax from a candle to seal the cap of the jar, and the straw to the cap. You don't want air to get into or out of the bottle.

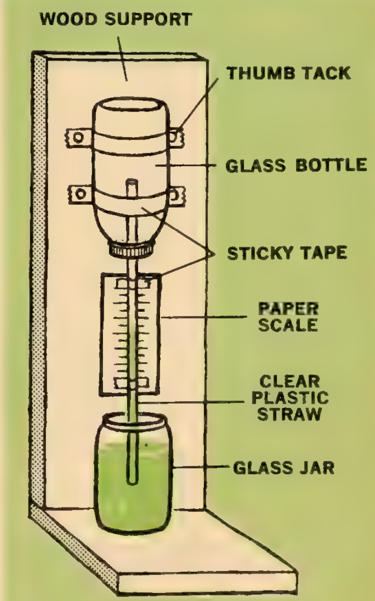
Make a wood support *(see diagram)*. The glass bottle should hang upside down so that the straw sticks into the water in the jar. When you put the straw into the water, water will not flow up into the straw. To get water up into the straw, you will have to heat the bottle a little. Try warming it with your hand. This will cause air in the bottle to expand and will force some of the air out through the end of the straw—you'll see bubbles. When you let the bottle cool for several minutes a column of water will rise inside the straw. The water replaces the air you forced out.

If you tape a narrow sheet of paper to the back of the straw, you will be able to calibrate, or mark, your air thermometer any way you wish. In what way is the copper-wire thermometer like the air thermometer?

In the next issue of *Nature and Science,* the second of this series of three articles will explore the world of intense cold and describe what happens to certain things when they are put in a scientist's deep freeze ■


This thermometer can be made out of wood, part of a coat hanger, a piece of copper wire, a nail, some glue and sticky tape, scraps of cardboard.
NAIL STICKING OUT FROM WOOD ABOUT ¾" AND BENT DOWN SLIGHTLY
COPPER WIRE (#12 TO #16 SIZE) 12½" LONG
CUT-OFF END OF COAT HANGER SLIPS INTO HOLE ABOUT 1" DEEP
ABOUT 14" HIGH
CARDBOARD SCALE TAPED TO WOOD
CUT AND BEND COAT HANGER TO MAKE POINTER ARM
ABOUT 5½" HIGH
ABOUT 5½"
ABOUT 20"

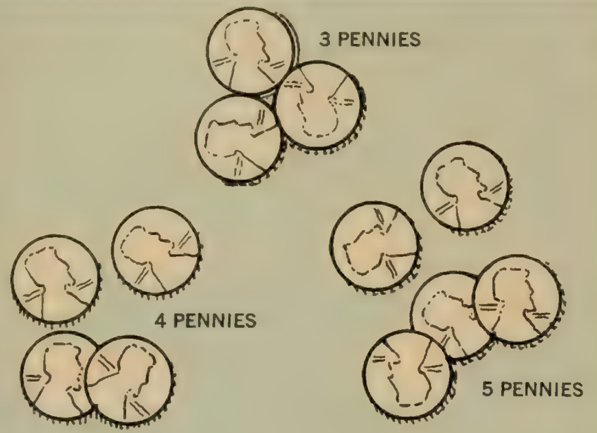
COPPER-WIRE THERMOMETER


WOOD SUPPORT
THUMB TACK
GLASS BOTTLE
STICKY TAPE
PAPER SCALE
CLEAR PLASTIC STRAW
GLASS JAR

AIR THERMOMETER

prepared by DAVID WEBSTER

brain boosters



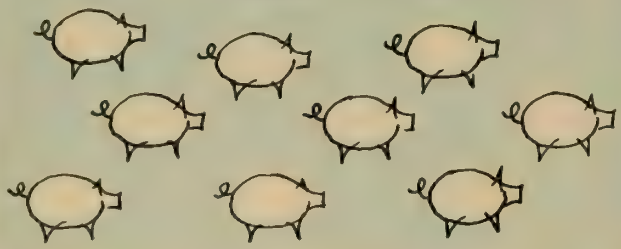
CAN YOU DO IT?

Here are 3 pennies arranged so each one touches the other two. Can you make 4 pennies each touch the other 3? Can you arrange 5 so that each penny touches the other 4?

FUN WITH NUMBERS AND SHAPES

Put these 9 pigs in 4 pig pens with an odd number of pigs in each pen.

Submitted by Sylvia Barel, Ithaca, N.Y.



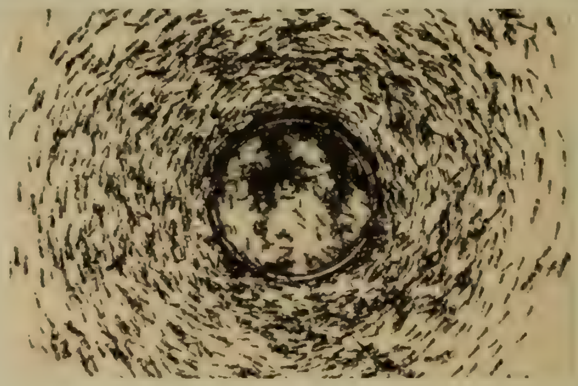
FOR SCIENCE EXPERTS ONLY

Can you explain this science contradiction:

> When you blow on a small campfire, it *burns better*. When you blow on a match, it *goes out*.

CAN YOU DO IT?

Can you push a soda straw all the way through a raw potato?



MYSTERY PHOTO

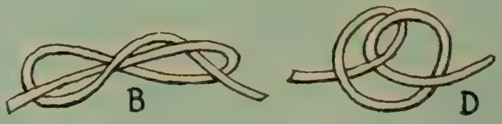
Why are these army ants going in a circle around the dish?

Answers to Brain-Boosters appearing in the last issue

Mystery Photo: The grooves in the mud are tracks left by earthworms.

Can You Do It? Here is the secret message: That's the way the ball bounces.

What Would Happen If . . . ? After the candles have burned awhile, the stick will go down on the right side. How could you arrange the two burning candles and the weight so the stick would stay balanced?



Fun with Numbers and Shapes: Strings A and C would end up without knots. The knots which would be made by strings B and D are shown.

For Science Experts Only: To get across the river, you could tie the rope to a tree at one side of a bend in the river. You could then walk around the bend and tie the other end of the rope to a tree on the other side of the bend. By swinging from the rope and moving hand-over-hand, you could get to the other side of the river.

THERE'S MORE TO COLOR THAN MEETS THE EYE

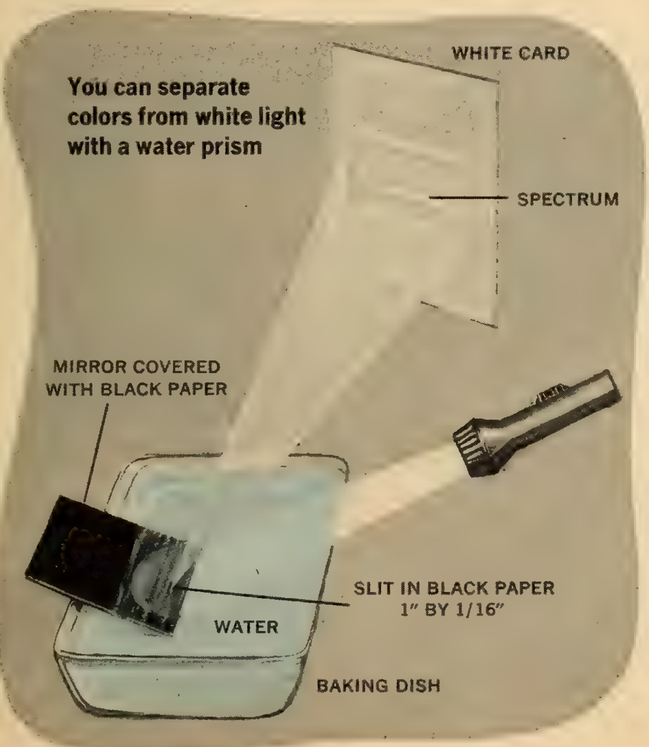
By splitting white light into light of different colors and putting lights of different color together, you'll find that–

by Diane Sherman

■ Rainbows, blue sky, green grass–color is all around us. But there's more to color than you might think. Here are some things you can do to find out more about color.

You will need a glass baking dish, a small mirror, a piece of heavy black paper, or aluminum foil, and a piece of white cardboard a foot or more square. Fill the dish with one to two inches of water and put it near a sunlit window. Cut a slit about one inch long and 1/16 inch or less wide in the black paper, or foil, and wrap it around the mirror.

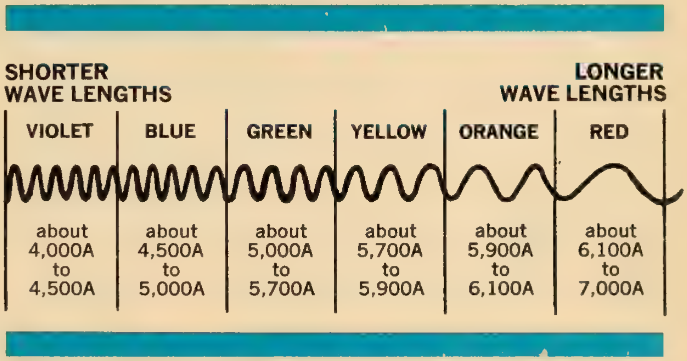
Now put the mirror in the water at one end of the dish *(see diagram)*. The mirror should lie at a slant against the side, with something propped in front to keep the mirror from sliding. Now hold up the card, as shown in the diagram, and move it around until you catch a rainbow of colors. The spread of colors in a rainbow is called a *spectrum*. Move the card back and forth until you get the sharpest separation of colors.


You can separate colors from white light with a water prism
WHITE CARD
SPECTRUM
MIRROR COVERED WITH BLACK PAPER
SLIT IN BLACK PAPER 1" BY 1/16"
WATER
BAKING DISH

Colors and Waves

Where does the spectrum of colors come from? All the individual colors are in ordinary sunlight. Like a glass prism, the water separates the white sunlight into its individual parts, or colors. It does this because light travels in waves of different lengths. At the ocean shore, or by a lake, you have seen waves washing up onto the sand. Sometimes the waves are spaced closely together; sometimes they are far apart. If you could suddenly stop the waves and freeze them, you could measure the distance between wave peaks. This is called the *wave length* of the waves.

The wave length of ocean waves can be measured in feet or yards. But light waves are so very much shorter that scientists use smaller units to measure their length. One such unit is the *Angstrom* unit. An Angstrom unit is so small that there are 254 million of them to an inch. Your eyes can detect light waves ranging only from about 4,000A to about 7,000A in length. When sunlight, or the light from your desk lamp reaches your eyes, all of those



SHORTER WAVE LENGTHS — **LONGER WAVE LENGTHS**

VIOLET	BLUE	GREEN	YELLOW	ORANGE	RED
about 4,000A to 4,500A	about 4,500A to 5,000A	about 5,000A to 5,700A	about 5,700A to 5,900A	about 5,900A to 6,100A	about 6,100A to 7,000A

(Continued on the next page)

wave lengths are present, so you see white light. It is when the longer waves are separated from shorter ones that we see colors.

In your water dish experiment you separated light of different wave lengths. That is why you saw a rainbow pattern of colors. You separated the longer waves (which make red light) from the shorter ones (which make violet light). In your spectrum, the colors lined up in this order—violet, blue, green, yellow, orange, red. But there was not a sharp division between the colors. The divisions are fuzzy.

Are White and Black Colors?

If someone asked you if white is a color, how would you answer? What about black? Is it a color? If you answer yes, what would you guess the wave length of black to be? Remember, our eyes cannot detect wave lengths shorter than about 4,000A or longer than about 7,000A.

Separating Colors from White Light

Your water dish experiment showed that the individual colors making up white light appear in a certain order. Why should they? The answer is that when white light enters the water the individual colors, or waves of different lengths, are bent by different amounts; the shorter waves are bent more than the longer waves. Because of this, the waves of different lengths come out of the water in different places *(see diagram on page 13).*

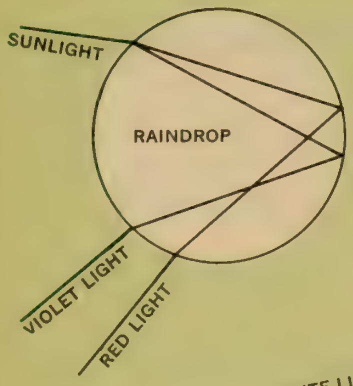
This is also what happens when you see a rainbow. Small drops of water in the air separate the sunlight into waves of different lengths by bending them different amounts before they reach your eyes. You can make your own rainbow in the early morning or late afternoon. Stand with your back to the sun and spread a fine spray of water around in the air in front of you with a hose. You should be able to see a rainbow in the spray.

All the colors in sunlight pass through clear materials, such as window glass. But colored glass or colored cellophane lets waves of only certain lengths through; other waves are stopped or filtered out. Such substances are called *filters*. Let's see how they work.

Prop a big white card where it will catch the spectrum. Now hold a piece of red cellophane between the card and the mirror. What happens to the spectrum? What color does the cellophane let through? Now try a piece of blue cellophane. Each color of cellophane absorbs, or soaks up, some of the colors of white light.

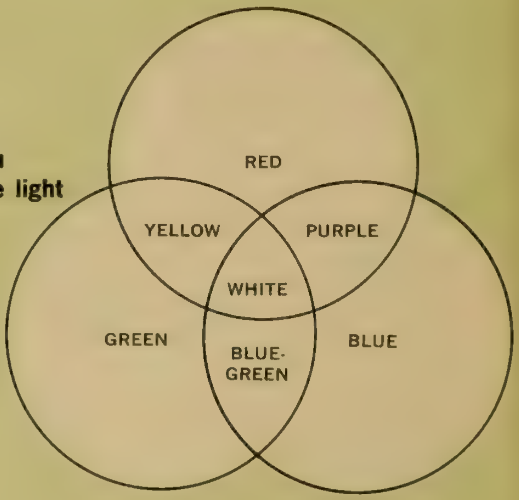
Color by Subtraction

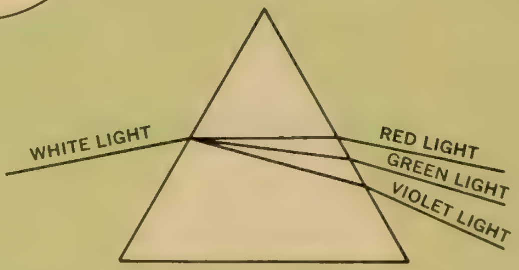
Why are the different things around us—books, carpets, houses, butterflies—different colors? They all have "filters" of a sort, called *pigment*. Pigment absorbs some colors and reflects other colors back to our eyes. Whatever color a pigment reflects is the color the object appears to be. A certain pigment in our blood absorbs light waves shorter than about 6,100A, so our blood appears red. A certain pigment in green plants absorbs waves shorter than about 5,000A and longer than about 5,700A. That is why grass



A raindrop separates colors from sunlight as your water prism does

What happens when you add red, green, and blue light





Light of shorter wave lengths bends more than light of longer wave lengths when passing through a prism

is "green"; the light waves it reflects are those between 5,000A and 5,700A in length.

Pigments subtract some colors from the spectrum by absorbing them. Most of the colors we see in nature are caused by this kind of "subtraction." A black object is black because it absorbs, or subtracts, all of the light shining on it. It does not reflect any of the colors.

BRAIN TEASER

Roses are Red,
Violets are Blue.
Turn out the lights,
What wave lengths come through?

P.S. Is a red rose still red at midnight?

Color by Addition

We can get color another way, too. You will need three flashlights that produce small spots of light. Fix two or three layers of red cellophane over one flashlight. Tape two or three layers of green cellophane over another, and two or three layers of blue over the third. Now take the flashlights into a dark room. Prop up the red one so it is shining on a white cardboard screen. With one hand hold the green flashlight at the same distance from the screen and shine it on the red spot. What happens? Now, with the other hand, shine the blue flashlight on the same spot. Is there any change?

If the lights from all of your flashlights were of equal strength, and if your filters were exactly the right color, the spot of light you saw would be white. But usually white light can be made in this way only in a laboratory, with special equipment.

Red, green, and blue light can be added together in pairs to produce other colors of light, as shown in the three-circle diagram. You can test this with your filter-covered flashlights or by making a color wheel *(see instructions at end of this article)*.

Can you guess what would happen if you put layers of both red and green cellophane over a single flashlight and switched it on? Try it and see. Can you explain what you see? Remember that a red filter subtracts light of every color but red from the white light, and a green filter sutracts light of every color but green. Does it make any difference which filter is closer to the light bulb? Do other combinations of red, green, and blue filters produce the same result?

What Would Happen If . . .

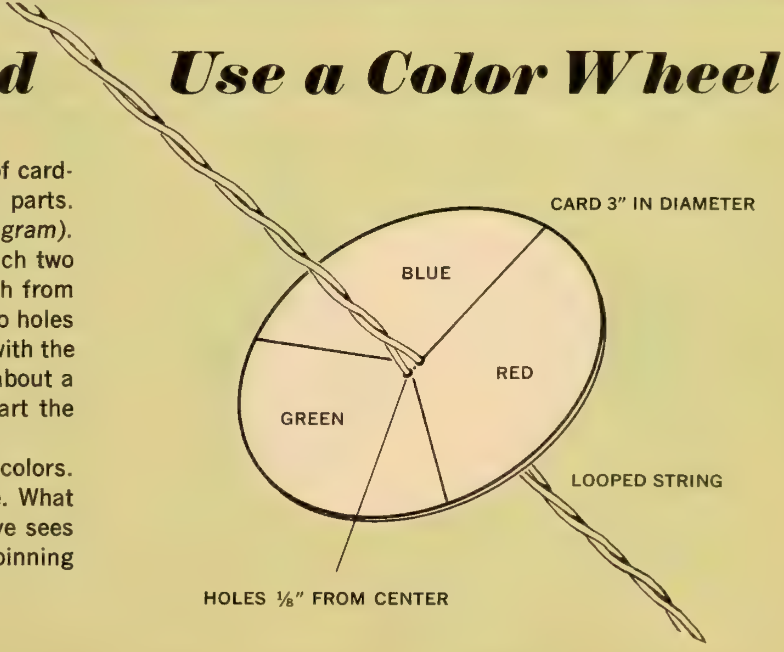
. . . the layers of color film shown in Diagram 2B on page 16 were colored with red, green, and blue dyes? Remember that the layers are used as filters. Compare the colors of dye that are used in the film layers with the colors of light you got by adding red light to blue light, red to green, and blue to green.

You can see that there is more to color than meets the eye. There is even more to color than we have explored here. (For example, what happens when you mix pigments of different colors together?) But that is another story ■

How To Make and Use a Color Wheel

Use a compass to draw a two-inch circle on a piece of cardboard. Cut it out and mark the circle in three equal parts. Color one section blue, one red, and one green *(see diagram)*. Use strong, bright colors, like poster paint. Now punch two holes in the wheel. Each one should be about ⅛ inch from the center. Loop a long piece of string through the two holes and tie the ends together. Hold one end in each hand with the wheel hanging loose, and swing it around in circles about a dozen times. Then pull the ends of the string to start the wheel spinning.

What happens to the colors? Try mixing different colors. Make a wheel half blue and half yellow, for example. What colors do you see when you spin the wheel? (Your eye sees the two colors of light that are reflected from the spinning wheel as if they were added together.)



HOW IT WORKS

Photographic Film

■ When you take a picture you let light into your camera for a fraction of a second. This light forms an image in the back of the camera which is a tiny, upside-down picture of whatever is in front of the camera. The image falls on the film which is in the back of your camera.

The film has a coating of chemicals that contain silver. In the places where the image in the camera is bright, a lot of light hits the film. In those places, tiny grains of pure silver are formed on the film. You can't see these grains unless you use a microscope, but where there are a lot of them together they make the film black. Where the image is dark, not much light hits the film. In those places few grains of silver are formed, so the film is gray or even lighter *(see Diagram 1)*.

When the film is *developed,* the chemicals that were not exposed to light are washed away. After that, light will not change the film any more. The tiny grains of silver remain on the film in the places that were exposed to light. This developed film is called a *negative,* because its light and dark areas are just the reverse of the image in the camera.

To make a *positive,* or picture just like the image in the camera, light is sent through the negative onto a piece of paper that is coated with the same sort of chemicals as the film. The paper is then developed. Where the negative is dark the positive will be light, like the original image.

How Color Film Works

Color film works the same way as black-and-white film. Color pictures are not really recorded in color. The colors you see when you look at a color slide come from dyes that are put into the film when it is developed. A color film is really three black-and-white films put together like a sandwich *(see Diagram 2A)*. Each of these films records light of a different color. In the top layer silver is formed only by blue light; the middle layer is sensitive to green light, and the bottom layer to red light. All the other colors of light can be made by mixing light of these three colors in different proportions *(see page 15)*.

Some color films are developed into negatives and used to make color prints, but most color films are developed in a different way to make positive slides. The film layers are dyed different colors. The top layer is dyed yellow, the middle layer purple, and the bottom layer blue-green. These dyes are dark where the original image in the camera was dark, and light where the image was light.

For example, in a place where the image in the camera was blue—like the sky in an outdoor picture—the top layer of film has little or no yellow dye. When you look through the slide at a white light, the blue-green and purple layers stop, or *filter out,* all of the colors of light except blue. So that part of the film will look blue. All the other colors are made in the same way—by filtering out some colors from the white light *(see Diagram 2B)*. —David Linton

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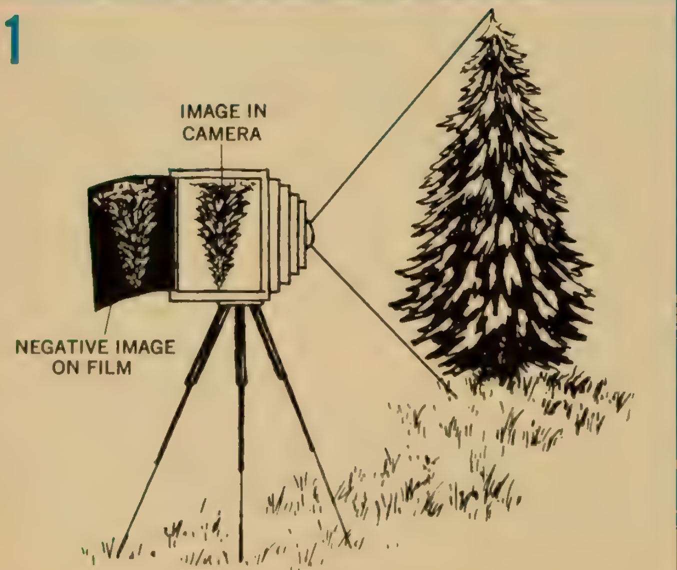

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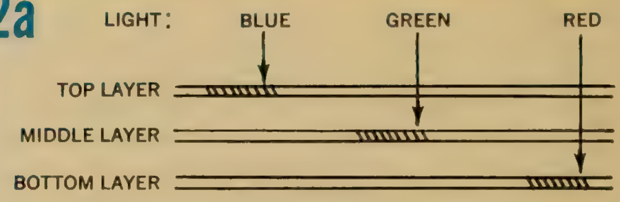

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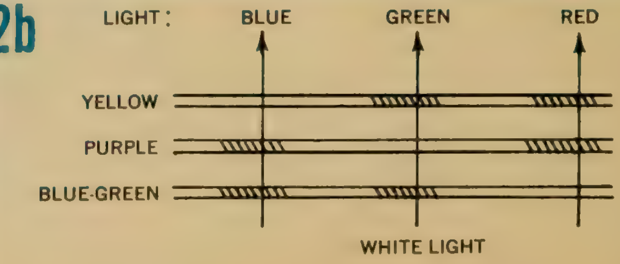

Using This Issue...

(continued from page 2T)

perature—say 86°—to centigrade, you must first subtract 32 degrees, then multiply by 5/9.

86°F−32°F=54°F; 5/9×54=30°C

To change a temperature reading from centigrade to Fahrenheit, multiply by 9, divide by 5, then add 32.

- Your pupils can see the expansion and contraction of a solid, a liquid, and a gas in the copper-wire thermometer, an alcohol or mercury thermometer, and the air thermometer. Have them think of other noticeable examples. For example, when a metal cap sticks on a glass jar, hot water on the cap will make it expand and loosen it. Concrete highways are divided into sections with narrow strips of asphalt between the sections. In summertime, the concrete sections expand and push the asphalt up to or above the level of the road. In winter, the concrete and asphalt contract, leaving gaps between the sections of concrete. The spaces between adjoining railroad rails are noticeably wider in winter than in summer.

You might also bring to your pupils' attention the warning on spray cans (of paint, shaving cream, etc.). If the gas that pushes the material out of the can gets too hot, it will expand and the can will explode.

Topics for Class Discussion

- *Can water be used in a thermometer?* Yes, but only at temperatures above its freezing point and below its boiling point.
- *Why are the degree marks on liquid, solid, and air Fahrenheit thermometers different distances apart?* The same amount of heat makes alcohol, mercury, solids, and air expand by different amounts.

13 More to Color

So many variable factors affect the colors we see that it may be well to point them out to your pupils as they do the investigations suggested in this article. For example:

1. Light must contain all the wave lengths of visible light if it is to yield a complete spectrum of colors. (Some fluorescent lamps do not produce such light.)
2. The slit through which the light reaches the mirror must be very thin, or the water prism may produce a number of spectrums stacked on top of each other.
3. Colors removed from white light by filters will vary somewhat with the kind of filters that are used.
4. Colors that we see reflected from an opaque object depend on which wave lengths of light fall on the object, as well as on which wave lengths are absorbed by pigments in the object.
5. Finally, the colors we see depend on our eyes, nervous system, and brain. Light and color are sensory phenomena—the reactions in our brains to the physical phenomena that we call light waves. (To answer the "Brain Teaser" question: A rose is red only when it is reflecting light waves of a certain length *and* when someone is present to receive those light waves and distinguish them from light of other wave lengths.)

White *is* a color—the one we see when light of all colors is mixed together. You can reinforce this point by holding a magnifying lens between the prism and the screen on which a spectrum is projected. Move the lens back and forth until the light from the prism is brought together as white light on the screen.

Black, on the other hand, is not a color; it is simply the absence of light. A piece of black paper is not truly black, because it reflects a little light to the eye. A room with no light at all in it could be described as "black."

Red, green, and blue lights are called *additive primary* colors, because adding them together makes white light.

But a red filter and a green filter, for example, used together over a light source, absorb light of nearly all colors. That is why the layers of color film could not be dyed with red, blue, and green pigments *(see page 16)*. Instead, they are dyed purple, yellow, and blue-green—the same colors produced by mixing the additive primary colors two at a time *(see three-circle diagram, page 14)*.

Purple, yellow, and blue-green are called the *subtractive primary* colors. When used in pairs as filters, they filter out all but one of the three additive primaries, red, blue, or green. For example, purple and yellow filters will allow green light to pass through. That is why the layers of color film are dyed with pigments of the subtractive colors.

"I never see an uninteresting..."

(continued from page 1T)

and placed on modern maps. The kinds of trees and other plant life, the nature and abundance of wildlife—mammals, birds, and fishes—can generally be had from the old records.

As this information is assembled it can be used in many subjects. The immediate impact will come from spot comparison of present with original conditions. What has been replaced by highways and buildings? What changes have taken place in the quality of water and air? What plants and animals have disappeared? What has replaced them and where did the invaders come from? One could continue such a list of questions indefinitely and then miss, perhaps, some that would occur to youngsters.

Adventure heightens as the gaps are filled in. What resources or advantage led to settlement of the county and placing the villages or towns? Who were the settlers and what skills and interests did they bring? What industries were established, and how have they changed and why? This last may reflect the progress of scientific technology or, as in the case of woodworking and other fabrication, the exhaustion of raw materials. Every angle of such an inquiry has its relation not only to biology, but to the physical and the social sciences. Study can go into as much depth as circumstances permit, and be used, not to water down the conventional subject matter, but to make it alive.

More than this, this practice provides a concrete and clinical approach to the problem of conservation. The subject is no longer a matter of words and pious exhortation. Going at it as I have suggested has many advantages. It encourages observation of what is at hand. It is a remedy for one of the frequent weaknesses of conservationists whose heart may be in the right place but who are short on solid information and good judgment. And it opens a workable scheme for interplay among the various subjects in the curriculum.

Outdoor Laboratories Are Helpful

Wherever possible there should be available—both as a community asset and teaching aid—an area of natural plant and animal life. Such outdoor laboratories are very different from

(Continued on page 4T)

"I never see an uninteresting..."
(continued from page 3T)

the highly manicured areas we call parks. They are, in many ways, as important as laboratories within the school buildings; nor is their value limited to the teaching of biology, for they are living examples of physical and chemical process.

If undisturbed nature preserves cannot be found, it is worthwhile to take whatever space can be had. With even a few years of protection an area can become interesting and significant.

Actually the problem of resource management has facets that touch almost any subject now offered, both in science and other disciplines. When we set it apart we run the danger of making it seem like special pleading and propaganda. Ideally, every teacher, whatever his field, ought to understand its serious importance and refer intelligently to it in the course of his normal work. History, for example, has too long been taught without reference to the often decisive role of resources in the rise and fall of empire. Whether we think of Hitler's drive for Near Eastern oil or the efforts of Greece and Rome to expand their supplies of grain and oil, we are concerned with resource problems.

Nor can we understand many of the critical problems of our own country, at home or abroad, unless we view them in the light of the pressure of numbers on a fundamental and finite resource—namely, space.

Planning With Other Teachers

Is it too much to suggest that groups of teachers, whether blessed or unblessed from above, arrange to meet under conditions as relaxed as possible from time to time? Let them have a calendar which will give each a chance to consider, in turn, the way in which conservation is related to the subject he handles. He should be equally free to suggest to others how they could, without distortion of their regular course plans, reinforce his own efforts.

It might well be that the teachers of science would have to initiate such a program. But if it be carried out, and if my own experience be any guide, it should result in a meeting of minds far more effective than the imposition of new and formal courses into an already bulging curriculum ■

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TEACHER'S EDITION

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◄N&S REVIEWS►

Recent Physical and Earth Science Books for Your Pupils

by Thomas G. Aylesworth

Biographies of Scientists

Benjamin Franklin, Scientist-Diplomat, by Charles Michael Daughterty; **Archimedes, Mathematician and Inventor,** by Martin Gardner; and **Space Pioneer, Galileo Galilei,** by Arthur S. Gregor (Macmillan, 41 pp., $2.95 each) bring Macmillan's Science Story Library to some eight titles. Of these three, the Galileo biography is perhaps the most rewarding, since the central character stands as a man of his world, rather than as a single-dimensioned person existing in an ill-defined environment. Galileo was a product of his times.

On the other hand, Archimedes and Franklin seem so superior to the other characters in these biographies that they emerge as superhuman tinkerers, rather than human beings. In addition, Franklin the diplomat is given short shrift, and some of the Archimedes stories are embroidered and told as truth. All of the books, however, are usable for supplementary reading in the upper grades. They may be over-illustrated, though.

Leonardo Da Vinci, The Universal Genius, by Iris Noble (Norton, 220 pp., $3.50) is another matter. Here is a three-dimensional man found in a book that is complete enough to give a full range picture of one of the greatest human beings in history. Well-written with a sense of history, this book will be a wise investment for the school library.

Science Activities

Junior Science Book of Water Experiments, by Rocco V. Feravolo (Garrard, 64 pp., $1.98) is more than an experiment book. It is almost a unit book. The activities are suggested within the framework of a total study of water. Thus, as the child is experimenting with evaporation and condensation, he is learning about the water cycle. A good book for the middle grades.

Science fairs and how to enter them is the theme of **Your Science Fair Project,** by William Moore (Putnam, 155 pp., $3.50). But it is more than a cookbook. A question is asked (statement of the problem). Suggestions for research are given (working with hypotheses). Suggestions for science fair displays are listed (drawing conclusions). And then, further questions are asked. The student is not given too much help. This is an excellent reference for students from grades 3-9, and for the teacher who needs ideas for student research.

The Young Experimenters' Workbook: Treasures of the Earth, by Harry and Laura Sootin (Norton, 58 pp., $2.90) is just that—a workbook. In this volume will be found a wealth of information on geological testing from testing for hardness to evaluating the clay content of water.

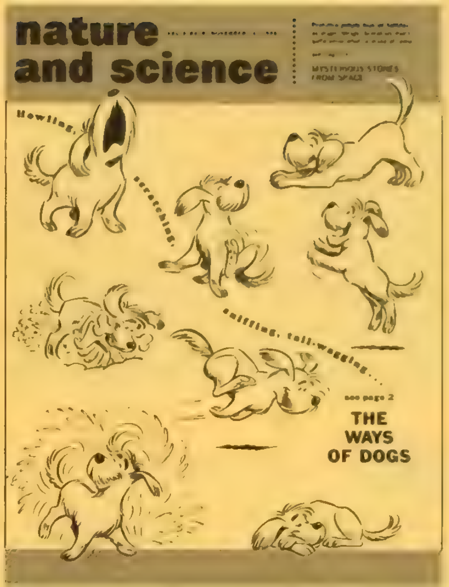
Science

Electricity in Your Life, by Irving Adler (John Day, 123 pp., $3.95); **The First Book of Energy,** by George Harrison (Watts, 75 pp., $2.65); and **Light You Cannot See,** by Bernice Kohn (Prentice-Hall, 67 pp., $3.50) are all quite good (although I cannot help wishing that Watts could retitle their "First Book" series. One would hope that a student would not have to get to fourth grade before he got his "First Book" of anything). But the first two of these books have certain drawbacks.

Both Adler and Harrison are good, no-nonsense writers. Actually, their books are fascinating. However, their books contain very little more subject matter than would be found in a good up-to-date junior high school text. And merely saying on the jacket or in the publicity release that the books are for third or fourth graders does not make

(Continued on page 4T)

Dr. Thomas G. Aylesworth is a member of our National Board of Editors.



IN THIS ISSUE

(For classroom use of articles preceded by ●, see pages 2T and 3T.)

● **The Ways of Dogs**
This article tells your pupils how scientists design experiments to investigate behavior and learning in dogs.

The Case of the Green Lemons
Some simple investigations on fruit ripening that children can try, using tomatoes, bananas, and some jars.

Our Work Horses in Space
Nine man-made satellites and how they are used to relay communications and to gather information about space.

● **How Cold Can It Get?**
Scientists measure extremely cold temperatures by the Kelvin or absolute scale. This article tells how and why men are probing the world of near absolute zero.

Mysterious Stones from Space
Tektites have been found in many parts of the world. Scientists offer different theories to explain where tektites came from.

How To Take Milk Apart
By separating curds, whey, sugar, and other ingredients from milk, your pupils can learn about the chemistry and food value of this "perfect" food.

IN THE NEXT ISSUE

How life comes to a new island . . . A WALL CHART and WORKSHOP on bird nests, their evolution, and how to study them . . . How hot can it get? . . . Make your own microscope . . . The story of an ornithologist's investigation of the life of a common bird—the chimney swift.

USING THIS ISSUE OF NATURE AND SCIENCE IN YOUR CLASSROOM

2 Ways of Dogs

Scientists are still not certain where dogs came from. Most of the evidence supports the idea that today's dogs can be traced back to wolves. The earliest known dogs lived about 10,000 years ago; their fossil bones were found with human remains in Denmark. During the many centuries since dogs were first tamed, they have served man as guards, hunters, messengers, pets, and in many other ways.

For all the thousands of years that dogs have lived with humans, dog behavior is still poorly understood by most dog owners. This article will help children make observations of their dog's behavior. It also gives them insight into how scientists go about studying an animal's behavior.

Topics for Class Discussion

- *Why do you suppose the scientists chose to study dogs that were small and all about the same size?* With dogs of the same size, the same apparatus could be used in the tests. Also, small dogs can be kept in smaller quarters and eat less than larger dogs.
- *Do you think a dog's performance on a test would be affected by a past success or failure? If so, how?* Success or failure affect motivation, and Scott and Fuller found especially strong evidence of this in the manipulation test *(see diagrams on page 6)*. The more a dog failed, the less it tried new ways of solving the problem. This emphasizes the importance of success in enhancing motivation, an important factor in learning situations with other animals, including humans.

You might ask your pupils whether they feel more like doing something (playing baseball, or painting a picture, for example) when they are succeeding, and less like trying to do the same thing when they are having trouble doing it well.

- *Why is the period from four to eight weeks of age so important in a dog's life?* What happens to a dog in this period determines how it will get along with other dogs and people. "Getting along normally" with other dogs does not mean that a dog will never fight with other dogs. Such fights may be normal, depending on the dog's environment.
- *Is there a similar "critical period" in humans?* There probably is, but much more study is needed on this theory. So far, the evidence (from observations of adopted children and of children separated from their parents while confined in hospitals) suggests that the vital period of socialization in humans extends from about six weeks to six months. Children taken from their parents and/or put in strange surroundings during this time often have strong emotional disturbances.

10 How Cold?

This is the second of the articles exploring heat and cold. In the last issue, "How To Make a Thermometer" presented the following concepts: (1) heat is a form of energy of atoms and molecules in motion; (2) heating a substance means adding energy to its atoms and molecules, with the result that they move about faster and rebound more vigorously when they collide, making the substance expand; and (3) cooling a substance means removing energy from its atoms and molecules with the result that they move slower and rebound less vigorously when they collide, making the substance contract.

The article in this issue deals with the world of very low temperatures—far below those encountered by your pupils. (The study of low temperature physics is called *cryogenics*, from the Greek word *kryos*, meaning "frost.") The concluding article will deal with the world of high temperatures.

Suggestions for Classroom Use

The discussion of temperature scales suggested in the last Teacher's Edition (page 2T) makes a good starting point for discussion of the Kelvin scale. Conversion of temperatures from centigrade to Kelvin is simple, because the degree units on both scales are equal; only the numbering is different. The diagram on page 10 gives a number of key temperatures on the three scales—Kelvin, centigrade, and Fahrenheit.

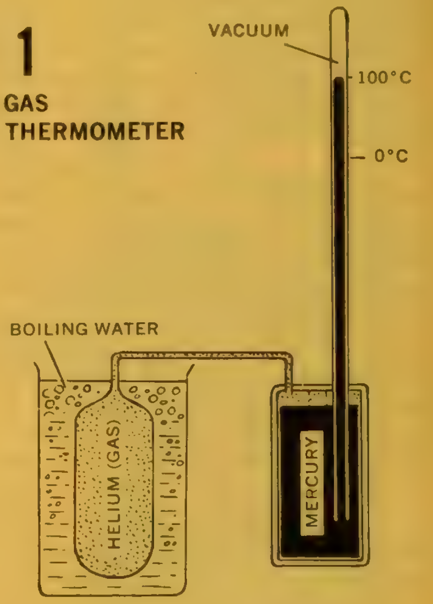
Your pupils may wonder how "absolute" zero, or 0°K, was set at the precise figure −273°C (actually −273.15°C). In 1848, the British physicist William Thomson (who later became Lord Kelvin) worked the whole thing out theoretically. Here is how he went about it:

Kelvin knew that gas thermometers are more accurate than other kinds of thermometers, because all gases expand by the same amount with each degree of temperature rise. (Most solids and liquids do not expand by exactly the same amount with each degree of temperature rise.) You might point out that the air thermometer described in the first article of this series is a simple kind of gas thermometer.

When the gas in the thermometer is heated *(see diagram 1)*, it expands

(Continued on page 3T)

1 GAS THERMOMETER



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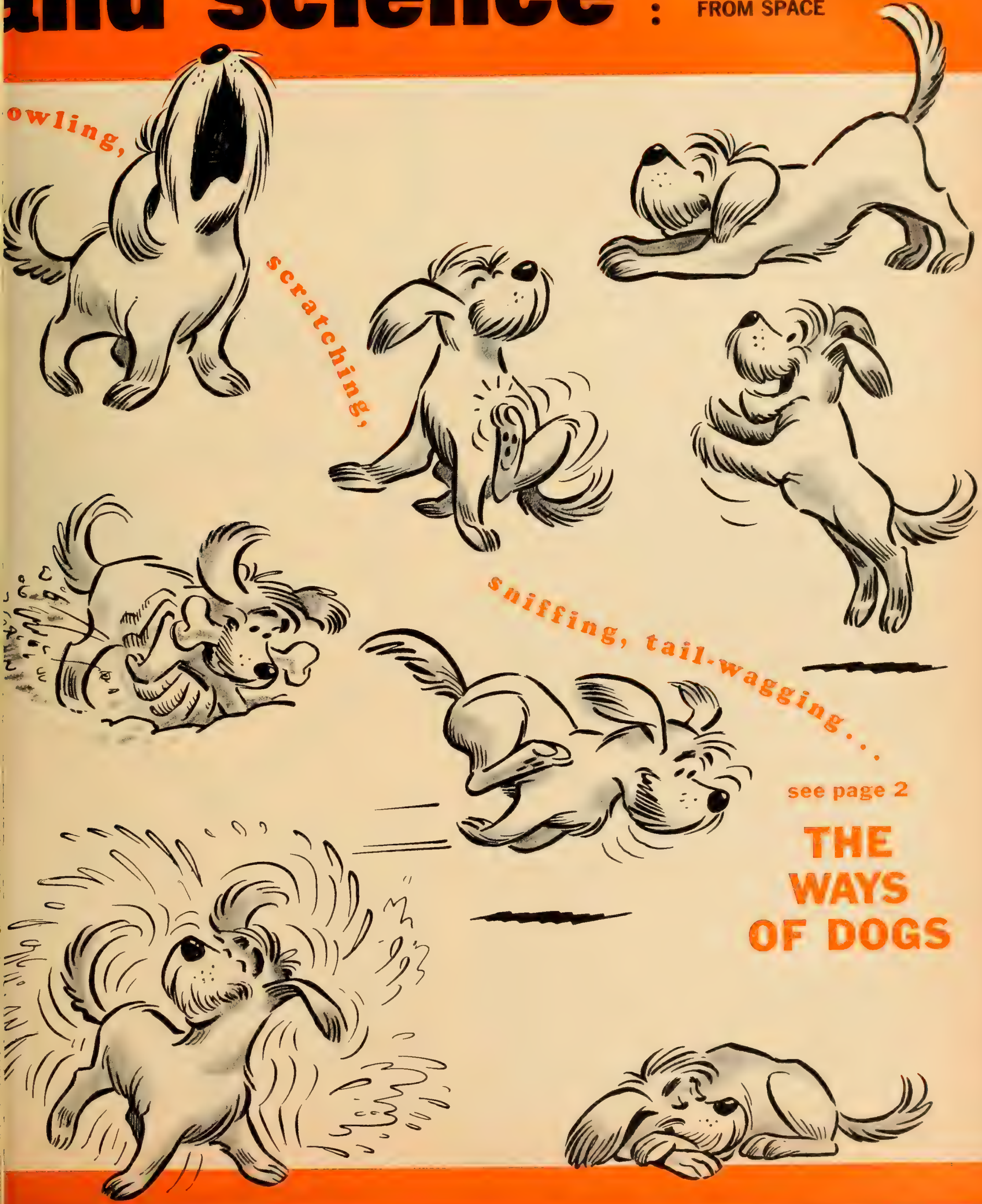
nature and science

VOL. 3 NO. 5 / NOVEMBER 15, 1965

Primitive people look on tektites as magic things. Scientists don't quite know what to make of them.

see page 14

MYSTERIOUS STONES FROM SPACE


owling,
scratching,
sniffing, tail-wagging...

see page 2

THE WAYS OF DOGS

nature and science

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the ways of DOGS

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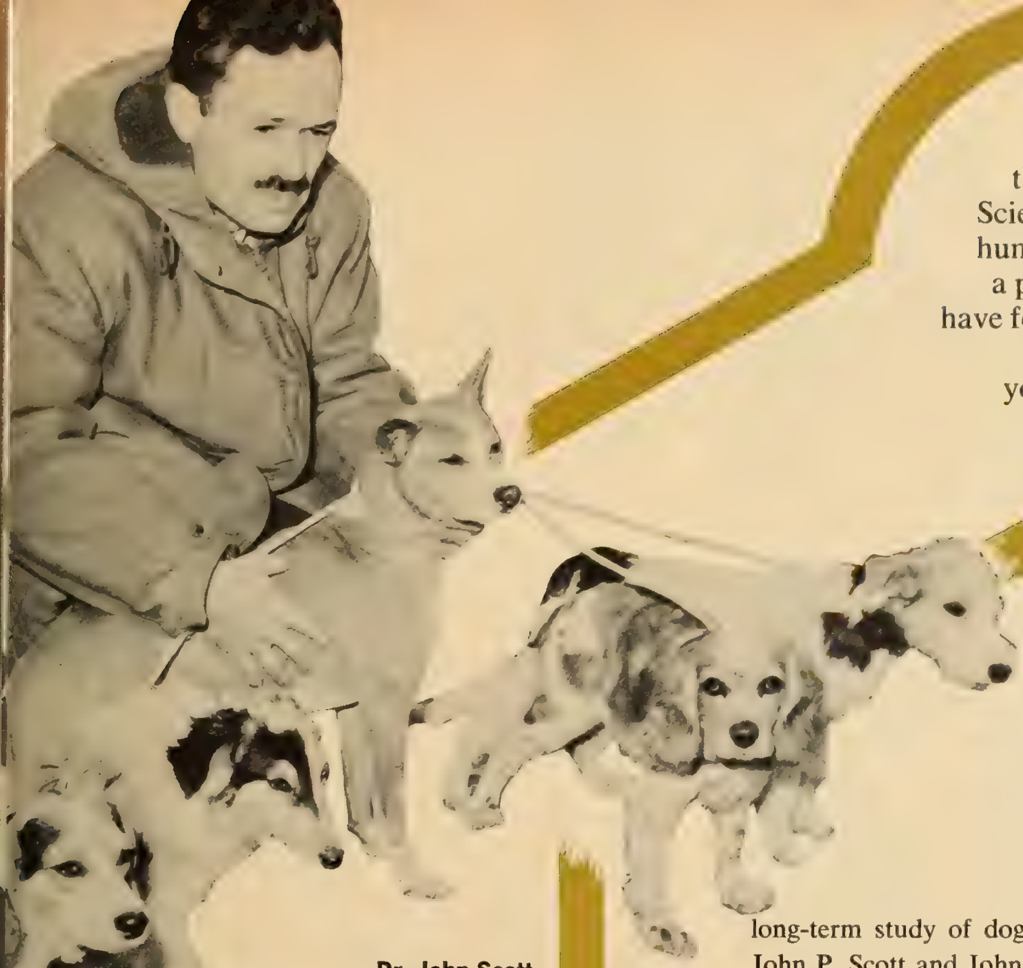
Why does
your dog act
the way he does?
Scientists who studied
hundreds of dogs over
a period of 13 years
have found out some things
that may help
you to understand
your dog's
"personality."

by Laurence Pringle



Dr. John Scott holds the five breeds of dogs that were studied: (from left to right) beagle, sheltie, basenji, cocker spaniel, and fox terrier.

■ Four-legged, childish humans dressed in fur coats—that is how we sometimes think of dogs. Instead, they are complex animals whose ancestors were wolves. Even though dogs have lived with humans for about 10,000 years, we know amazingly little about why they act as they do.

Why do some dogs make good pets while others do not? How do humans affect the ways in which dogs act? Many pet owners have wondered about these questions. Now, after dozens of different experiments with hundreds of dogs, scientists have some answers.

In 1947, a group of scientists met in Maine to plan a long-term study of dog behavior. Two of the scientists, John P. Scott and John L. Fuller, were to spend the next 13 years finding out about the ways of dogs. They led a team of scientists and students who investigated the behavior of dogs at the Jackson Laboratory in Bar Harbor, Maine. The lab, set in the country, consists of three barnlike buildings surrounded by about five acres of dog runs. The runs are enclosed by four-foot-high wooden fences. Scientists at the lab discovered many things about dog behavior that can be used by dog breeders and by anyone who owns a dog.

Planning a School for Dogs

One of the first questions that Dr. Scott and Dr. Fuller had to answer was: What breeds of dogs should we study? They looked for different breeds that showed the greatest differences in behavior. After observing dozens of different breeds, they decided to use five that were all about the same size—beagles, American cocker spaniels, Shetland sheep dogs (shelties), wire-haired fox terriers, and basenjis (short-haired, "barkless," dogs from Africa).

Once the dogs were selected, the scientists made sure that all the breeds had the same living conditions. They

(Continued on the next page)

This article has been adapted from parts of the book, Genetics and the Social Behavior of the Dog, *by John Paul Scott and John L. Fuller, published by the University of Chicago Press, Chicago, Illinois. The article is printed by permission of the publisher.*

The dogs were given many problems to solve. In this one, they had to climb a ramp to reach a dish of food on top of boxes five feet high. Basenjis did best, although they usually approached the boxes with caution. Cockers did almost as well. They ran to get a head start up the ramp.

The Ways of Dogs (continued)

wanted to be sure that there were no differences in food or handling, for example, that would cause differences in the animals' behavior.

Then the study of behavior began. It was not easy, especially at first. "One of the difficulties with studying dogs," explains Dr. Scott, "is that everyone knows dogs. Each of us tried to write down what the dogs did. Our first notes usually indicated that dog B_1 moved across the field, while dog B_2 moved down the field, with very little other information. We were so familiar with the details of dog behavior, such as tail wagging and sniffing the ground, that we overlooked them entirely. As time went on, however, we began to notice these details and realized that this was precisely the kind of information we wanted. In later notes we began to describe such details. To give an actual example: 'B_7 again plays with pup. Pup rolls over—cries. B_7 sniffs pup—pup runs—pup wags tail—cries loudly. B_7 playing with it—chasing it. Pup growls at B_7.' "

After many months of study, the scientists had a list of about 90 things that dogs do—their "patterns of behavior." The list includes items like these: scratching self, burying food, whining, tail wagging, and howling—alone or in a group *(see cover)*.

Most of these observations were made from hidden places overlooking one-acre fields where different groups of dogs were surrounded by high wooden fences. The scientists wanted to find out how the dogs acted with no humans around. They found that in many ways, dogs act very much like their ancestors, the wolves.

Next, the scientists began watching litters of puppies. Each day a trained observer watched the pups for 10 minutes through the windows of the nursery rooms. The observers wrote down everything the pups did. As they watched the animals from day to day, the pups hardly seemed to change. But after looking at all their notes and observations, the scientists discovered that the pups had gone through a remarkable series of changes.

Puppies into Dogs

A newborn puppy is blind and deaf. When it feels pain, cold, or hunger, the pup makes yelping noises (which it cannot hear) and crawls about at random. The puppy seems to have one goal—getting food from its mother.

Then, when the pup is about 13 days old, its eyes open and it begins to change rapidly. Within a week or two, a pup can walk, growl, play, and learn simple tasks. It can hear, and its first teeth begin to grow.

When a puppy is about 20 days old, it begins a new stage in its development. Until now, most of its actions have been aimed at getting food. Now it spends many of its waking hours playing with its fellow pups. The puppy begins to pay attention to the sight and sound of dogs and people at a distance. It begins to wag its tail. In humans, this would be the same as a baby's smile.

Dr. Scott and Dr. Fuller call this important time the "period of socialization"—the time when a puppy learns how to react to other dogs, people, and places. It lasts from about 20 days to 12 weeks of age. What happens to a puppy in this period has an important effect on its future "personality" as a dog. The period from about four to eight weeks is especially important.

The importance of this time in a pup's life was revealed in one study called the "wild dog" experiment. Large numbers of puppies were kept in the fields surrounded by high wooden fences. They were given food and water through openings in the fence, so they had almost no contact with humans.

At two, three, five, seven, and nine weeks of age, different groups of pups were taken from their pens and given

The puppies were given their first test when six weeks old. This pup was just set on the floor. Now he has 10 minutes in which to find his way around the U-shaped barrier to a dish of food at the girl's feet. Basenjis did best on this test; cockers and shelties did poorly.

a week of contact with humans. Then they were returned to the enclosed fields. One group of pups was left alone for 14 weeks. At the end of this time, all the different groups of dogs were brought to the lab. There they were given lots of tests.

In one of the tests, a scientist put a leash on each pup and led it through the lab building and up a staircase. The scientist counted the number of times that the pup balked at being led on the leash. The animals that balked the least were those that had been in contact with humans when they were five, seven, or nine weeks old. The dogs that had spent some time with humans at two, three, or 14 weeks of age did much worse. One pup that had little contact with humans for 14 weeks was given leash-training for a month and still showed little improvement.

A Well-Balanced Dog

Dog breeders, or anyone with a litter of puppies in the garage or basement, can learn a lot from these studies. Dr. Scott and Dr. Fuller suggest two rules for raising a "well-balanced" dog that gets along with other dogs and with people.

First, take a pup from its litter when it is between six and eight weeks old. If this is done earlier, especially at four weeks of age or younger, the puppy hasn't had much chance to develop normal ways of behaving with other dogs. All through its life it may get along well with humans, but not with other dogs. For example if such a puppy is a female, it may never be a good mother.

On the other hand, if a pup is kept with its fellow dogs for longer than eight weeks, it will get along well with dogs, but will probably be timid with humans.

A second rule is that a puppy should get a taste of its future adult life. If it is to be a house pet, it should at least visit a house several times before it is three or four months old. Dogs kept in a kennel until four months of age or older often do poorly in any other kind of life.

Whether or not a pup is raised in a kennel or in a home can also affect its behavior. Some of the puppies at the Jackson Laboratory were taken from their litters at four weeks of age and raised in homes. They lived the ordinary lives of pets, except that they were often taken back to the laboratory and tested. As they grew up, the dogs were more free and confident with human beings than kennel-reared dogs were. In tests, the home-raised dogs were less fearful of the human handler. Compared with kennel dogs, they were more active, stood more erect, and were more likely to explore their surroundings. Their home life gave them confidence when they were with people and when they were faced with tests.

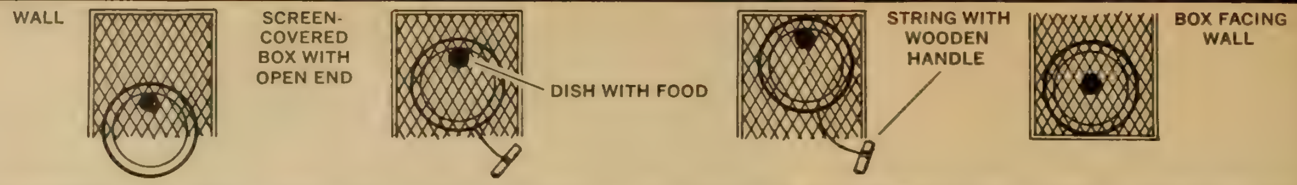
The work at the Jackson Laboratory revealed something else about dog behavior that may help you the next time you or your family are buying a puppy. Suppose you are standing in front of a litter of pups, trying to select one for a pet. Some of the animals come boldly forward. Others hang back. Which would you choose? Dog buyers often pick the pup that comes forward most boldly. Is it a wise choice?

It may not be. In litters of pups that are over five weeks old, certain dogs *dominate*, or "boss," the others. It is usually these pups that rush forward to meet humans. However, this doesn't necessarily mean that the pups that stay back are not attracted to people. When scientists took such pups from their litters and handled them, they found that some of the shy animals were strongly attracted

(Continued on the next page)

WHAT ABOUT YOUR DOG?

Make a study of your dog's behavior toward other dogs and people. Is your dog timid or confident with people? Does it usually avoid other dogs? Next, try to find out when the dog was taken from its litter (your parents or the dog breeder who sold the puppy can probably tell you). What conclusions can you draw from these facts? You might make similar investigations with the dogs of your friends.



These diagrams and labels show how a food dish and a screen-covered box were arranged in different ways to find out how well the different breeds could use their paws to get food from the dish *(see text below for results).*

to people. These pups were just kept away from humans by the more dominant dogs. Dog buyers who pick a bold, "bossy" pup are probably getting a dog that will be aggressive toward other dogs. A pup that is not so dominant may make a better all-round pet.

Problems for Dogs To Solve

When buying a dog, you should first decide what breed you want. For hundreds of years, people have bred dogs to produce special breeds that can do particular jobs. Each breed usually has one outstanding ability, and this ability often has an effect on the dog's behavior. Some of these differences showed up when the dogs at the Jackson Laboratory were given a series of problems to solve.

One problem was designed to find out how well dogs of different breeds could use their paws. First the pups were trained to run to a low wooden box with a food dish in it. When they next ran to the box, they found it covered with a wire screen. They could see and smell the food, but could only reach it by pulling or nosing the dish through an open side of the box. Each day after that, the box and the dish were arranged so that it was more difficult to get the food *(see diagrams)*. Of the five breeds tested, basenjis always did best on this problem. Beagles did poorly, and the rest of the breeds were in between.

Several other kinds of problems were tried on the dogs *(see photos on pages 4 and 5)*. No one breed always had the highest rank. The four hunting breeds (basenjis, beagles, terriers, and cockers) usually did best. Shelties did poorly, but this was probably because of the way the tests were designed.

If a dog did well on a test, he got a food reward. This didn't interest the shelties as much as the hunting breeds. Also, the tests were designed to be solved by the dog alone, without help from people. Shelties have been bred to herd sheep by following directions from their masters. In many of the tests they seemed to be waiting for someone to tell them what to do.

Dr. Scott and Dr. Fuller found that there are important differences in the abilities and behavior of the breeds they studied. However, they feel that all breeds can do a wider variety of things than most people realize. A German shepherd, for example, is normally used for herding, guarding, and as a "guide" dog for blind people. It can be taught to track animals, however. Most of the hunting breeds make fine house pets. And the collie, a herding dog and pet, can be trained to hunt.

Dogs are highly adaptable animals. If you have a dog, or plan to get one, remember that the kinds of things it can do and the way it behaves depends a lot on the kind of home and training you give it ■

■ To learn more about dogs look for these books in your library or bookstore: **The How and Why Wonder Book of Dogs,** by Irving Robbin, Wonder Books, Inc., New York, 1962, 50 cents (paper); **All About Dogs,** by Carl Burger, Random House, Inc., New York, 1962, $1.95; **Story of Dogs,** by Dorothy Shuttlesworth, Doubleday & Co., Inc., New York, 1961, $2.95; **Training a Companion Dog,** by Dorothy Broderick, Prentice-Hall Inc., Englewood Cliffs, N.J., 1965, $3.50.

INVESTIGATIONS

- Are dogs "right-handed" or "left-handed?" A silly question? No. We've heard of a boy who won a science fair prize by investigating this question. How would you go about finding out whether a dog favors its right or left foot? Does the experiment using a food pan in a box *(see above)* give you any ideas? If you answer this question, let us know how you did it and what you found out.
- Test the trailing ability of your dog and the dogs of your friends. First set up a simple trail (no more than 50 feet long) on a lawn or other open space. Make the trail by dragging a cloth soaked in meat or fish juice over the ground. Put a piece of meat or fish at the end of the trail as a reward.

Then lead your dog to the beginning of the trail and see how well he does. If he fails to follow the trail, lead him along it to the food reward. Then, with the dog out of sight, make another trail of the same length in a new spot and try again. Jot down the length of the trail and the time needed to solve the problem.

Try the same test with other dogs, using a trail of the same length and setting it up in a different area each time. You can also test the dogs with tougher trails. Remember that the weather can affect the trailing ability of dogs and, of course, some breeds are better at following trails than others. Can you think of other factors that might affect a dog's skill on a trailing test?

The Case of the Green Lemons

by Richard M. Klein

■ In the early part of this century, farmers in southern California began growing lemon trees. The growers found that it was cheaper to pick all the lemons at once, even if the fruits were not all ripe. To ripen the lemons, they put them in a small room heated by a kerosene stove. Within a few days, the lemons were all ripe and ready to be packed and shipped all over the country. One day, however, a farmer decided to use a small electric heater instead of a smelly, smoky, kerosene stove. It must have been quite a shock when he found that his lemons did not ripen. And, of course, he lost quite a bit of money.

The farmer decided to find out just why his lemons ripened when the heat came from burning kerosene but did not ripen when the same amount of heat came from electricity. After several years, he discovered that the smoke of burning kerosene contains a gas that causes the fruit to ripen.

Twelve years later, in 1924, Dr. Frank Denny, working for the United States Department of Agriculture, found out that gas was one called *ethylene*. Farmers learned that they could ripen lemons faster by pumping this gas into chambers containing the fruit. A few years later, some other scientists found that ethylene could be used to ripen other fruits, such as tomatoes, bananas, melons, pears, and peaches. Today, ethylene is used to speed up the ripening of almost every fruit and vegetable we eat.

How You Can Use Ethylene

Kerosene smoke is not the only source of ethylene. Scientists have discovered that almost all fruits and vegetables give off ethylene gas as they ripen. Here are some ways you can investigate this invisible gas, right in your own kitchen or at school.

To test the effects of ethylene, you will need a source of the gas and an unripe fruit. One of the best sources of ethylene gas is a ripening banana. Buy one or more bright yellow bananas that have only a small amount of green color at their tips. This will be your source of ethylene.

The test fruit can be a small, green tomato. The kind that come in the cellophane-covered boxes are excellent for this purpose. They can be green or slightly pink in color and should be quite firm.

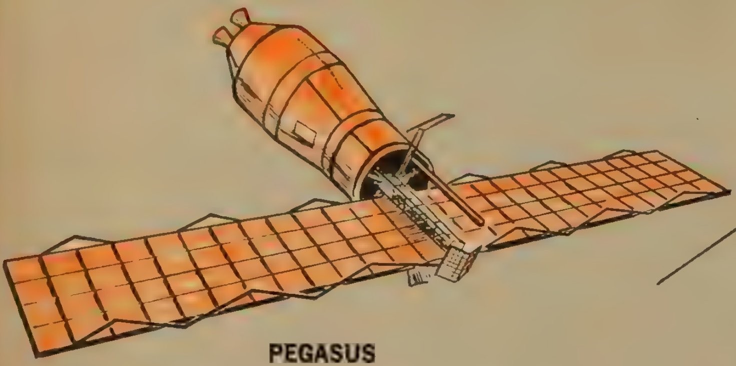
Put a ripe banana (the source of ethylene) in a wide-mouth, screw-top jar along with one small, hard tomato. Screw the cap on tightly and put the jar in a dark place. Try not to have the temperature too warm or too cool—70°F is about right. Put another unripe tomato in another jar—without a banana—then screw on the jar top and put it in the same dark place.

After a few days, look at the tomatoes. Which one is getting redder? When one tomato is a bright red color, take it out of the jar and taste it. Compare its flavor and texture with the second tomato. Which is riper?

You can use the unripe tomato test to find out how quickly ethylene gas is formed by other fruits. Use apples, pears, lemons, and just about any other ripe fruit as the source of ethylene, and unripe tomatoes as the test fruit. Does it take the same number of days for a tomato to turn bright red with each of the ethylene sources? Do you think that some kinds of ripe fruits give off more ethylene than others? Perhaps the size (surface area) of the ripe fruit has an effect on the speed of ripening. Can you think of a way to test this idea?

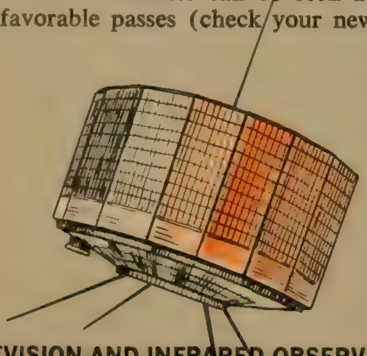
Scientists don't know whether or not ethylene gas is produced by plant parts other than fruits. Ethylene may be given off by flowers, leaves, stems, and even tubers such as potatoes. How would you find out? ■

Dr. Richard M. Klein is Caspary Curator of Plant Physiology at The New York Botanical Garden.



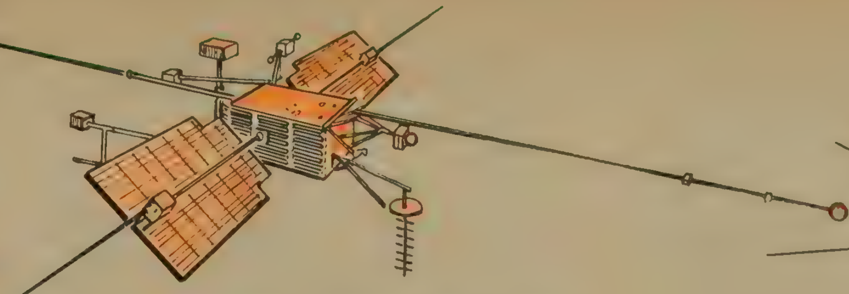
PEGASUS

PEGASUS satellites are designed to study the intensity of micrometeor bombardment of the atmosphere. These satellites have wings which are extended to make a 96-foot span after launching. Micrometeoroid impacts are recorded as the tiny rock fragments strike the surface of the 2,300 square-foot wings. PEGASUS satellites weigh about 3,200 pounds. They are the heaviest and, next to ECHO, the largest satellites launched by the U.S. PEGASUS I was launched May 25, 1965. The PEGASUS satellites can be seen at twilight during favorable passes (check your newspaper).



TELEVISION AND INFRARED OBSERVATION SATELLITE (TIROS)

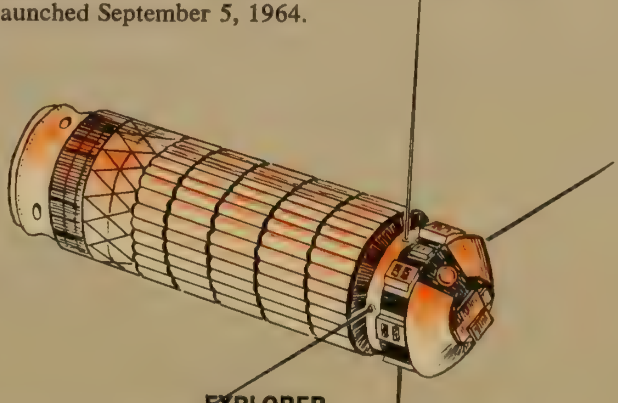
TIROS satellites are meteorological satellites. As their name indicates, they are equipped with television cameras which send back to earth pictures of cloud formations. These pictures enable meteorologists to improve the accuracy and timing of weather forecasts. Millions of dollars and many lives have been saved because of information about hurricanes and other dangerous storms given to meteorologists by TIROS satellites. The TIROS satellites weigh about 250 pounds and are about 19 inches high and 42 inches in diameter. They orbit from 370 to 600 miles above the earth.



ORBITING GEOPHYSICAL OBSERVATORY (OGO)

OGO satellites are designed to study space near the earth. They have two planned orbits. One orbit is extremely stretched out, or *eccentric*. Its closest point is 150 miles from the earth; its most distant point, 60,000 miles. The satellite in this orbit is called the Eccentric Geophysical Observatory (EGO). It measures high-energy radiation and the earth's magnetic fields.

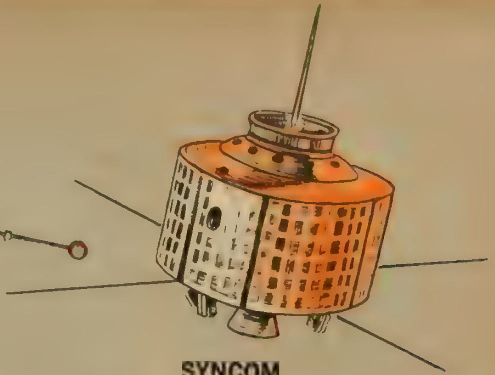
The Polar Orbiting Geophysical Observatory (POGO) is in an orbit about 140 miles above the earth. It passes over the North and South Poles. It studies the upper atmosphere, and particularly the atmosphere over the polar regions. OGO satellites are 6 feet long and 3 feet on a side. They weigh about 900 pounds. The first OGO was launched September 5, 1964.



EXPLORER

EXPLORER I was launched February 1, 1958. Its purpose was to check cosmic rays, micrometeoroids (tiny rock grains in space), and temperatures. The first Explorer detected the Van Allen Belt of radiation around the earth. Nearly 30 Explorer satellites are now investigating space near earth. They have no standard shape; each is built to carry out its particular mission.

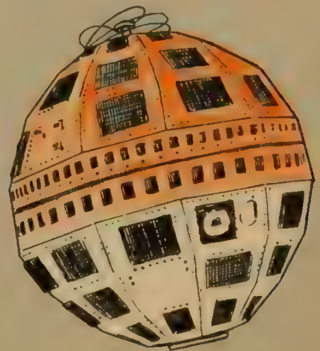
NUMBER OF ACTIVE SATELLITES NOW IN ORBIT	NUMBER OF ROCKETS AND OTHER DEBRIS IN ORBIT



SYNCOM

SYNCOM satellites are like TELSTAR satellites (they receive and re-transmit radio signals). But their orbits are not like those of TELSTAR. At a distance of 22,300 miles from earth, SYNCOM's period of revolution about the earth is almost the same as the period of the earth's rotation. This means that the SYNCOM satellites remain above the same part of the earth. Three SYNCOM satellites, equally spaced 120 degrees apart around the earth, will enable a radio signal to be sent to almost any point on the earth.

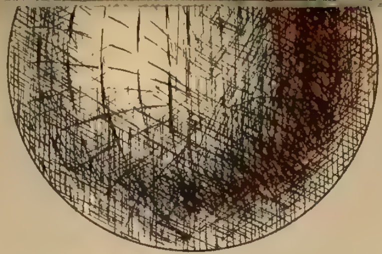
SYNCOM satellites are 28 inches in diameter, 25 inches high, and weigh 150 pounds. SYNCOM I failed shortly after it was launched. SYNCOM II was launched July 26, 1963 and is over the middle Atlantic near the Equator.



TELSTAR

TELSTAR satellites receive radio and television signals from the earth, strengthen the signals, then pass them on to receiving stations on earth. They also carry instruments for measuring radiation.

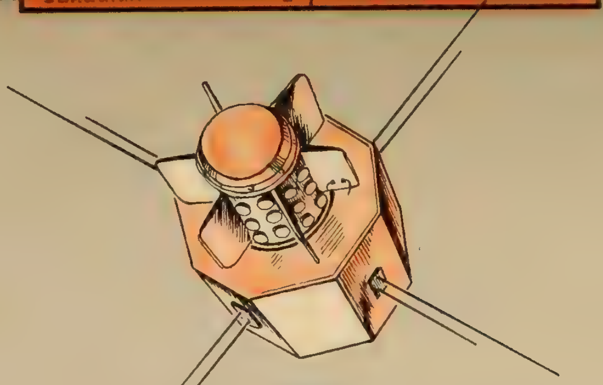
TELSTAR I, launched July 10, 1962, relayed the first telecast from the U.S. to Europe and the first live telecast from England to the U.S. Its orbit ranges from 593 miles to 3,503 miles above the earth. (TELSTAR I is no longer working.) TEL-



ECHO

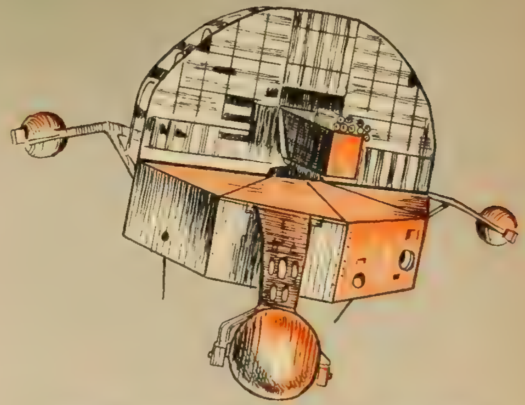
ECHO I is a sphere of aluminum foil 5/10,000 of an inch thick. The expanded sphere is 100 feet in diameter and weighs 132 pounds. Since it was launched on August 12, 1960, this satellite has been battered by micrometeoroids (tiny rock grains in space) until it no longer has a spherical shape. Radio signals bounced off ECHO satellites from the earth can be made to travel greater distances than signals bounced off the ionospheric region of the atmosphere.

ECHO II is an aluminum sphere with a diameter of 135 feet and a weight of 165 pounds. It was launched January 25, 1964. ECHO II is in a nearly polar orbit. Both ECHO satellites can be seen at twilight during favorable passes (check your newspaper). ECHO satellites do not carry instruments.



TRANSIT

TRANSIT satellites are navigational satellites. As few as four of them, in proper orbits, can serve as navigational aids for ships and aircraft anywhere in the world. Five are now in orbit. Information sent to them is stored in automatic memory systems in the satellites, then broadcast automatically every 1¾ hours to ships and aircraft. TRANSIT IVA, launched June 29, 1961, carried the first nuclear power system into space. This is SNAP, the System for Nuclear Auxiliary Propulsion. The unit weighs 4½ pounds, and is powered by plutonium.



ORBITING SOLAR OBSERVATORY (OSO)

OSO is designed to study the sun from outside the major part of the earth's atmosphere. One of its main jobs is to forecast major solar flares—"storms" on the sun that emit x-rays and other high-energy radiation. In general, OSO satellites weigh about 440 pounds, are 37 inches high and 44 inches in diameter. They travel in orbits about 350 miles above the earth's surface. The first OSO was launched March 7, 1962.

OUR WORK HORSES IN SPACE

Eight years ago last month the Space Age began when the Soviet Union launched the world's first artificial satellite, Sputnik I. Since then, more than 700 satellites have been put into orbit, 540 of them by the United States.

Apart from manned satellites, the Mariner IV Mars space probe was the most dramatic. This small packet of instruments crossed 325 million miles of space in 228 days and passed within 6,100 miles of Mars—only three minutes off schedule. The excellent photographs it took of the Red Planet were a major achievement.

The work horses of the Space Age are the satellites that seldom make big headlines. Hundreds of them have been sent above the greater part of the earth's atmosphere, where they continue to travel around the earth. They send us information about space around us, and about the universe beyond. Other satellites serve as communications stations in space. Still others track and report hurricanes and other weather systems that affect our lives.

On these pages are drawings of some of the United States satellites and descriptions of what they do.

EXPLORING HEAT AND COLD

PART TWO

HOW COLD CAN IT GET?

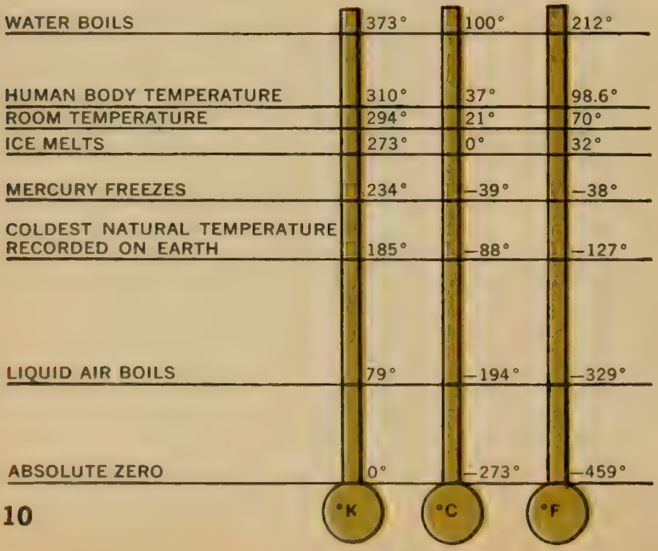
What's the coldest anything can get? Absolute zero? Maybe. Scientists are trying to find out.

by Roy A. Gallant

■ What's the coldest weather you've ever experienced? Zero? Ten below zero? Colder? The coldest natural temperature recorded on earth (800 miles from the South Pole) is –127°F. But by scientists' standards this isn't very cold. They want to find out what happens to things at *very* low temperatures, at –400°F and colder.

Discovering ways of making things colder and colder is a science adventure in itself. And finding out what happens to different substances—metals and living tissue, for example—at very low temperatures is equally exciting *(see box at end of article).*

When you read Part I of this article in the November 1 issue, you found that temperature is a measure of the speed at which the atoms and molecules of a substance are moving. In a gas, for instance, the atoms are zipping about freely, bumping into each other and bouncing off in all directions, like the players on a football field. In a liquid, the atoms are packed much more closely together. Although they can slip and slide past each other—like the people squeezing through the narrow ticket gate to see the game—they are not free to fly about. In solids, such as an iron bar, the atoms are locked together. They cannot move about at all. All they can do is vibrate in place, like the shivering crowd jammed at the exit gate after the game on a cold November day.



	°K	°C	°F
WATER BOILS	373°	100°	212°
HUMAN BODY TEMPERATURE	310°	37°	98.6°
ROOM TEMPERATURE	294°	21°	70°
ICE MELTS	273°	0°	32°
MERCURY FREEZES	234°	–39°	–38°
COLDEST NATURAL TEMPERATURE RECORDED ON EARTH	185°	–88°	–127°
LIQUID AIR BOILS	79°	–194°	–329°
ABSOLUTE ZERO	0°	–273°	–459°

When you say that it's "ten below" or "in the nineties," you are talking about degrees *Fahrenheit*. The Fahrenheit temperature scale is the one on your living room thermometer. But scientists—and most people living in other parts of the world—use the *centigrade* temperature scale. Ice melts at 32°F and 0°C. Water boils at 212°F and at 100°C *(see temperature diagram).*

Centigrade is fine for most purposes, but when scientists want to measure the temperature of things that are very hot (such as the sun), or very cold (such as the liquid oxygen in a rocket), they find it simpler to use the *Kelvin,* or *absolute,* temperature scale. On this scale ice melts at 273°, and water boils at 373°. Near zero degrees K, every substance we know of becomes a solid and its atoms and molecules vibrate hardly at all. The world of absolute zero is a strange one.

Going Down . . .

Imagine now that we have a box of air at room temperature, about 300°K. What we want to do is cool the air. To put it another way, we want to slow down the molecules, so that they fly about with less vigor. (Let's call them "air molecules," although they are really molecules of the gases, such as oxygen, nitrogen, and water-vapor, that make up air.) As the physicist would say, we want to reduce the molecules' energy of motion, called *kinetic energy.*

One way we could do this would be to hold the box under cold water. The molecules of the cold water have less kinetic energy than the "air molecules" in our box. Gradually, the "air molecules" in the box lose some of their kinetic energy to the cold water outside the box. Heat, or energy, is not really lost, though. It is simply transferred from the hotter air in the box to the cooler water flowing over it, thus warming the water.

As the "air molecules" slow down, some of them join when they collide, instead of bouncing apart. For example, some of the molecules of water vapor join each other and form little drops of water that cling to the box walls. By cooling the air, we have changed some of the water molecules that were in the air from a gas to a liquid.

If we now remove heat from the water drops by putting them in a refrigerator, the water molecules move even slower than before. In fact, they slow down so much that they no longer are able to slip over and around each other and move from one place to another. They become locked together and vibrate in place, like the atoms and molecules in a bar of iron. We now have a solid, ice. The ice feels cold when you touch it because you are warmer than the ice, but there is still some heat in it. So long as its atoms and molecules continue to vibrate, there is heat in it.

Scientists wondered if it would be possible to take *all* the heat out of a substance. If they could, would its atoms come to a complete standstill and stop vibrating? Would this be absolutely the coldest anything could get? Is *absolute zero,* or 0°K, the lowest possible temperature in the universe? Or is it possible to go even *beyond* absolute zero?

Cooling a Gas by Heating It

Before giving one scientist's answer to this question, let's find out one of the ways *very* low temperatures are reached. Suppose that we have a container of gas, say ammonia, at room temperature. Suppose also that we can squeeze the container, thus crowding, or *compressing,* the gas molecules. This makes them move faster and bump into each other more often and with greater force. By crowding the molecules closer together, we have given them more kinetic energy. In other words, we have made the gas hotter.

Liquid air is about —320°F. When poured onto the floor at room temperature, liquid air becomes a gas, or boils.

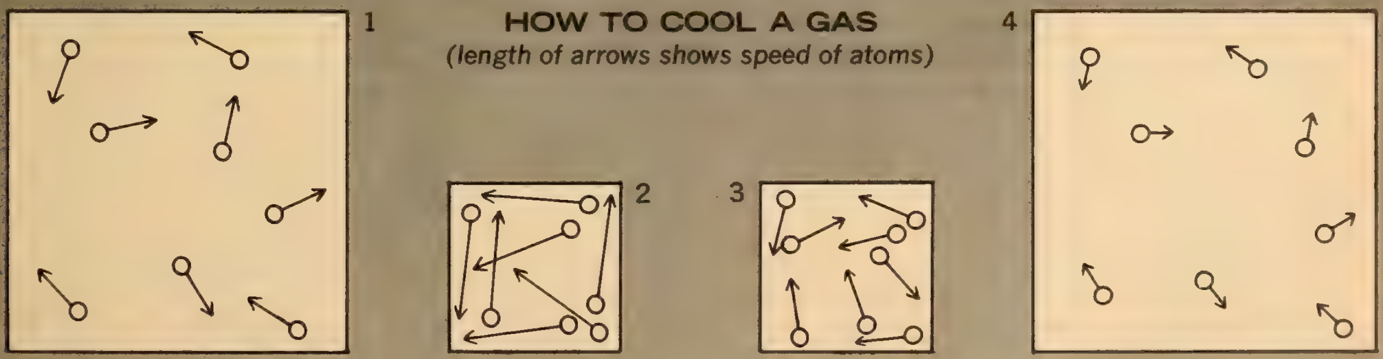
This may seem to be an odd way to begin cooling something, but it is only the first step *(see diagram).*

Next, we hold the container in a tank of very cold water. The gas molecules now give up some of their energy (heat) to the slower moving water molecules. This continues until the temperature of the gas and the water is the same.

Why did we bother to squeeze the container before holding it under water? Why not just dunk it without squeezing it? Wouldn't the gas have cooled just as much? Yes, it would, but remember that the container is still squeezed. When we release it, something will happen. The force of the gas molecules battering the inside wall of the container causes the container to swell out to its original size.

The molecules now have the same amount of space they

(Continued on the next page)



In container 1 are atoms of a gas at room temperature. Squeezing the gas (2) adds energy, or heats the gas and makes its atoms move faster. Holding the container under cold water cools the gas (3), slowing down the atoms. Letting the atoms push the container out to its original size (4) causes the atoms to lose energy, or cool.

had at the beginning. But something has happened to them. It takes energy to push the walls of the container outward. In pushing the sides of the container out to its original size, the molecules lose some of their "go-power," or kinetic energy. They are now moving slower than they were before we released the container. In other words, the gas has been cooled a second time. Its temperature is now lower than the room temperature.

What would happen if we repeated the cycle—compressing the gas by squeezing the container, cooling it, then releasing the container to let the gas expand again? The ammonia gas would, of course, cool still more. If we repeated the cycle again and again, the ammonia gas would eventually lose so much of its heat that it would become liquid ammonia.

Have you ever heard of liquid air? Scientists can make liquid air by starting with ordinary air and cooling it in the way just described. Ammonia gas turns into a liquid at about 240°K; air turns liquid at a much lower temperature (79°K). In order for air to remain liquid, it must be kept at 79°K, or colder. If it is warmed above 79°K, its molecules have so much energy that they no longer remain joined. They fly off in all directions, thus becoming a gas. This action, changing from liquid to gas, is *boiling*.

How Cold Can It Get?

To reach temperatures even colder than liquid air, scientists have to use gases whose atoms or molecules join together less easily than the atoms and molecules of ammonia or air. Helium is one such gas. It is very hard to make ordinary helium atoms join together. What we are saying, of course, is that it is very hard to turn helium gas into liquid helium. To do so, the temperature must be lowered to about 4°K. No other substance can be cooled this much without becoming a solid. Helium alone is a liquid at about 4°K. By treating liquid helium in a certain way, scientists can cool it still more, to about 0.4°K.

STRANGE WORLD OF COLD

Dry ice, with a temperature of about —112°F, is hot enough to make the liquid nitrogen in the kettle boil, or turn to a gas.

They do this by pumping away the vapor that tends to form at the liquid helium's surface. Those atoms that pop out of the liquid and thus become vapor are, of course, the more energetic ones. Pumping them away leaves the liquid with a greater number of sluggish (or "colder") atoms.

This is about as cold as scientists can make anything by using the compression-expansion method, or "squeeze cycle." But they have found another way of reaching even lower temperatures. They use powerful magnets to slow down the motions of atoms. A substance called cerium magnesium nitrate has been cooled to 0.005°K by this method. But this is not the end of the low temperature story. By lowering the temperature in still a different way, they have managed to squeeze out so much heat from certain atoms that their temperature was lowered to 0.000001°K—one millionth of a degree from absolute zero! Is it possible to make things even colder than this? Dr. D. K. C. MacDonald, the late Canadian low-temperature physicist, wrote that "the story has not finished yet, and I for one would not be rash enough to predict that it must stop somewhere!" ■

In the next issue we will explore the world of extreme heat and try to answer the question "How hot can it get?"

Why Bother To Make It Cold?

Interest in very low temperatures is rapidly moving out of the laboratory and into our lives.

Engineers are fascinated by the effects of low temperature on the flow of electricity. If a ring of wire is supercooled and electricity is fed into it, the current keeps flowing round and round the ring, never stopping. At extremely low temperatures, the wire loses all resistance to the flow of electricity. It's as if you started an electric train, then immediately turned off the current, but the train coninued moving round and round the track forever.

Recently, surgeons have been using an "ice scalpel" to remove unwanted tissues of the body. The ice scalpel is a thin tube holding liquid nitrogen. If your tonsils are frozen for about 10 minutes with liquid nitrogen, the tonsils will gradually disappear in about three weeks.

Scientists have also been experimenting with living tissues and organs. Certain organs have been removed from the body (a chick's heart, for instance), slowly cooled down to the temperature of liquid air, and stored away. When the organ is gradually warmed up to room temperature, it goes to work again, apparently unharmed.

This experiment with a chick's heart suggests a fascinating question: Would it ever be possible to cool a human being down to the temperature of liquid air so that the person could hibernate for tens or hundreds of years?

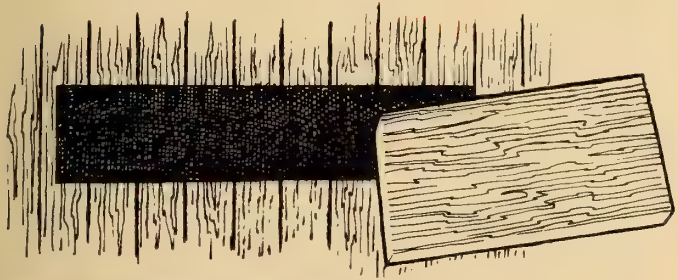
According to Dr. MacDonald, "Naturally enough, no one yet suggests that this kind of fantastic experience could be attempted today with anything as complex as a whole human being, but perhaps the day will come, when, if you want it, you can arrange to 'hibernate' for a thousand years or so in liquid air, and then be 'awakened' again and see how the world has changed in the meantime. Even Rip van Winkle, or the Sleeping Beauty, might pale in envy at this length of 'sleep'."

BRAIN-BOOSTERS

prepared by **DAVID WEBSTER**

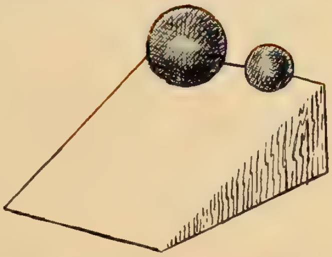
Can You Do It?
If you drop a paper match, it will land on its side. What can you do to a paper match to make it land on its edge?

For Science Experts Only
Why is it possible to drive a golf ball a tiny bit farther in Denver than in Miami Beach?



Fun with Numbers and Shapes
Suppose you had a hole that was 2 feet wide and 9 feet long, and you had a piece of wood measuring 3 feet by 6 feet. How could you cut the wood into two pieces so it would fill in the hole?

What Would Happen If
...you rolled a big ball and a little ball down a ramp? Which would reach the bottom first?



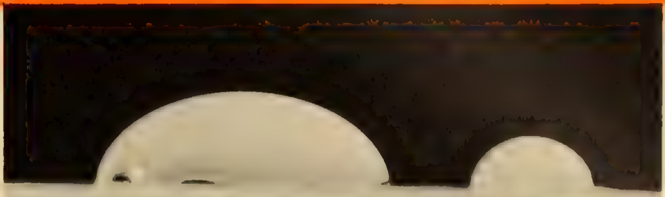
Can You Stump Mr. Brain-Booster?

Here is another contest for all readers of Brain-Boosters (including adults). Can you give me a puzzle that I can't solve?

Just send me your toughest Brain-Booster *without* the answer. If I am unable to solve it, I'll write and ask you for the answer. To the ten who send the best puzzles by December 1, I shall award a copy of the *Bone Picture Book*. Some entries will be printed in Brain-Boosters, for which the usual $5 will be paid.

I'll bet you can't stump me!

Mail your Brain-Booster to:
Mr. Brain-Booster
Bedford Lane
RFD #2, Lincoln, Mass. 01773

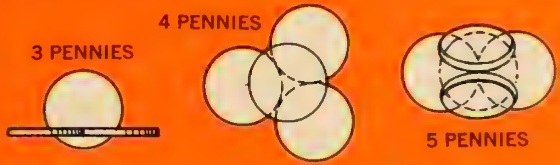


MYSTERY PHOTO

The photograph shows a side view of two water drops. What is unusual about the shape of the drops?

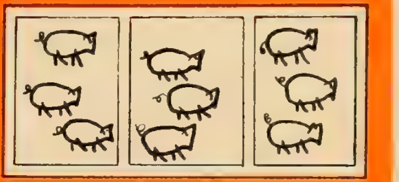
Answers to Brain-Boosters in the last issue

Mystery Photo: Army ants are blind and find their way by smell and touch. A few of the ants in the photo went around the dish; the rest followed their scent trail until all were circling the dish.



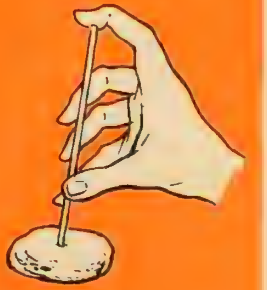
Can You Do It? The diagram shows how to arrange the pennies.

Fun with Numbers and Shapes: *(See diagram.)*



For Science Experts Only: With a small fire, such as a burning matchstick, the wind from your mouth blows the flame right off the matchstick. If the fire is bigger, however, the flames are too large to blow away. Instead, the air you blow on a campfire provides the fire with more oxygen, which makes it burn better.

Can You Do It?: To push a straw through a raw potato, hold it as shown. Then make a hard, straight jab at the potato. With a little practice you should be able to drive the straw right through. It is important to hold your finger on the end of the straw, since the air trapped inside makes the straw more rigid.



Primitive people see them as magical things. Scientists don't quite know what to make of them. What are these

MYSTERIOUS

by Edward R. Ricciuti

■ Scattered about the ground in several parts of the world are smooth glassy stones that once rained on the earth from the sky. These black stones are called *tektites*. The name comes from the Greek word for "molten." Where tektites came from has baffled astronomers for many years. From the moon? Possibly. Yet some scientists think that they were once part of our own planet.

Tektites have been known for many years. One scientific account of them goes back to 1787 and describes them as a kind of volcanic glass. Other people have thought that tektites might be rocks that had been melted by forest fires. Still others wondered if tektites could be solidified "drops" from the sun, or fragments of another planet.

The biggest known tektites are about the size of a baseball. If you hold one up to a lamp or sunny window, you can see light through its edges.

Tektites have been found in many parts of the world, including Texas, Georgia, Massachusetts, Africa, and Eastern Europe. The best places to look for them, however, are in southeast Asia and Australia.

Dr. Brian H. Mason, one of the world's busiest tektite collectors, has visited Australia's desert regions three times during the last three years to search for the puzzling black stones and for clues to their origin. Since tektites are named after the places in which they are found, scientists call Australian tektites *australites*. At least forty thousand australites have been found, according to Dr. Mason, who is Curator of Meteorites at the Smithsonian Institution, Washington, D.C. On his three expeditions, Dr. Mason and two others collected 3,000 australites.

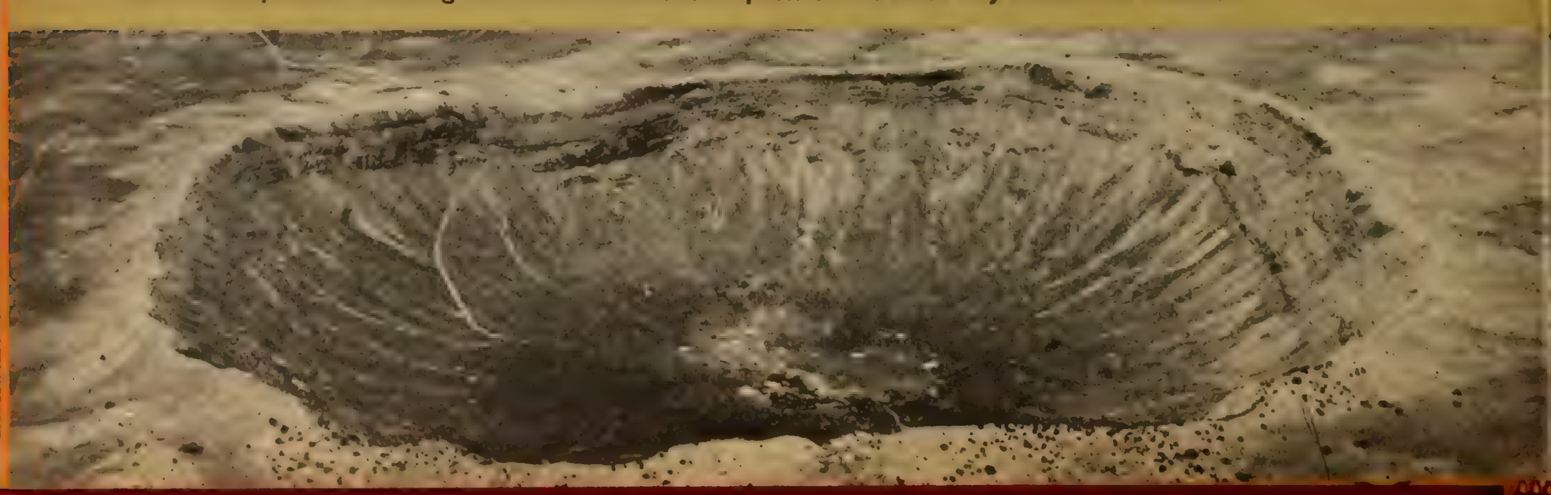
Scientists think that tektites—however they were formed—fell on the earth in prehistoric times, some of them millions of years ago. However, Dr. Mason thinks the australites may be relative newcomers; he believes they dropped from the sky only a few thousand years ago.

Case of the Australian "Buttons"

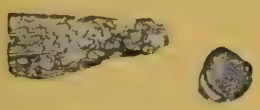
Some australites resemble small buttons trimmed with a thin *flange*, or rim. Only australites have this shape *(see photo)*. Tektites found in other parts of the world are shaped like balls, teardrops, dumbbells, or irregular chunks of rock. Over the years, these tektites have been worn smooth by the action of wind, rain, and sand.

How did australites get their button-like shape? That is one part of the tektite mystery which has been solved. When an object falls to the earth from space, it passes through the atmosphere. As the object picks up speed and rubs against more and more molecules of the gases that make up the atmosphere, it gets hotter and hotter. This *frictional heating* is what causes shooting stars. Called *meteors*, these are fiery streaks left by chunks of metal and stone that plunge into our atmosphere at a rate of thousands each day. From time to time, one of these chunks is so big that it does not completely burn up in the atmos-

A giant meteorite crashed into the earth some 20,000 years ago, forming this crater near Winslow, Arizona. Some scientists think that explosions resulting from similar meteorite impacts on the earth may account for tektites.



STONES FROM SPACE?



phere, and it crashes to earth as a *meteorite*. Over 500 meteorites hit the earth each year.

Tektites are heated by friction just as meteors—and space capsules—are. The heating is so intense, says Dr. Mason, that the surface of a tektite pushing against the air gets so hot that part of it melts. The blast of the atmosphere spreads the melted part from the front to the outer margin of the tektite. As the tektite is slowed down by the atmosphere, it cools off, hardens, and falls to the ground as a button-shaped object.

Recently, artificial tektites were made by an imitation of this natural process. Glass balls were placed in a hot-air blast in the laboratory. The pieces of glass melted and formed objects that resemble australites.

Why have some australites kept their button-shape? Why haven't they been worn smooth by wind and sand? Dr. Mason believes that they have not been on the ground long enough. The australites may have fallen from space only 5,000 or 10,000 years ago. The rough shapes of tektites found in other parts of the world, says Dr. Mason, are due to their greater age. The *moldavites*—tektites from eastern Europe—may be about 15 million years old. Tektites found in the United States may be about 30 million years old.

Tektites from the Moon?

Although scientists can learn something about the effects of atmospheric heating of tektites, they still cannot answer the most interesting part of the tektite puzzle: Where did they come from?

One answer was suggested in 1942 by Harvey Nininger, former director of the American Meteorite Museum in Sedona, Arizona. Tektites, he said, may be portions of rock splashed off the surface of the moon when the moon was showered by giant meteorites.

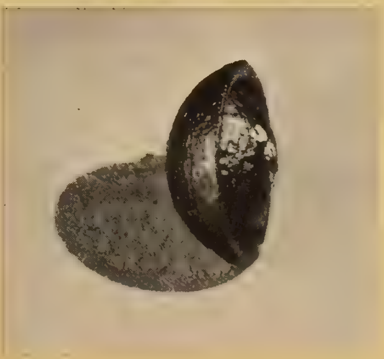
Since the moon has practically no atmosphere, these vast objects smashed into the lunar surface with great force. Some astronomers believe that the moon's craters are king-size holes blasted in its surface by huge meteorites. The force of the crash of a large meteorite might melt some pieces of the blasted moon rock and launch them into space. The pieces of melted rock, according to this theory, were splashed so far away from the moon that they were captured by the earth.

Tektites from the Earth?

There is a possibility that, instead of coming from the moon, tektites originated right here on the earth.

How could tektites have gone from the earth into space and back again? It appears that giant meteorites have crashed into our planet, as well as into the moon. Craters have been found in Arizona, Canada, Siberia, and elsewhere. Could collisions like those leaving craters have splashed melted rock high into space? And, is it possible that these rocks fell back to the earth as tektites? Some scientists think so. Dr. Virgil E. Barnes, of the University of Texas, has said that a large meteorite crashing into the Wilkes Land region of Antarctica could account for the australites. First, the tektites would have been splashed up through the atmosphere, then they would have orbited the earth once and landed in Australia. Dr. Barnes says that wherever a group of tektites is found, all the tektites in the group are the same age. Different groups have different ages. This would indicate that each group was formed by a separate meteorite collision with the earth.

As fascinating as these two ideas are, no one knows for certain where tektites came from. It will take a lot more scientific detective work to find out ■



As this australite plunged through the atmosphere, the air blast heated the front surface (left) and spread the edges backward, forming a rim around the back (right).

HOW TO TAKE MILK APART

■ Have you ever seen cream come to the top of milk? Most milk in stores has been *homogenized*—treated so the cream cannot rise to the top. But milk that has not been homogenized comes apart by itself. The cream rises to the top and can be skimmed off. Skim milk is left.

To take milk apart and find out what's in it, you will need some cream and some skim milk. If you leave some skim milk covered in a warm place, it will come apart by itself. How long does it take? A day? Two days? Is it smelly?

If you want to hurry things along, put 1 measuring cup (8 ounces) of skim milk in a clear glass jar. Heat it until it is lukewarm by putting the jar in a pan of hot water for about 5 minutes. Then mix the warm milk with ¼ cup of *white* vinegar. What happens to the milk?

The thick parts you see are *curds;* the watery part is *whey*—the diet of Little Miss Muffet. The curds are protein; protein makes body tissue.

You can separate most of the curds from the whey by pouring the mixture through a sieve. Let the whey drip into a bowl. Even though you strain most of the curds out, there will still be some left in the whey that drips into the bowl. You can get more of them out by pouring the whey, a little at a time, through cheesecloth. Add the curds from the cheesecloth to the curds in the sieve.

What To Do with the Curds: Put the curds on a paper towel, pat them gently with another paper towel, and spread them out to dry. Cottage cheese is made from curds. What do the curds feel like before they dry? After they dry? In powder form, curds are called *casein*. Plastic buttons are made of casein.

What To Do with the Whey: Does the whey look cloudy? Put it through fresh cheesecloth two or three times. What color is it? Whey comes apart when it is heated in a double boiler. During the heating you will notice some small white curds forming. These curds are milk *albumin,* and they are different from the curds formed earlier. Do they look different? Let the albumin curds dry. Do they feel, taste, or look like casein? Albumin is also a protein; it makes an important part of your blood.

Put the clear liquid left in the double boiler into the refrigerator for about 10 minutes. After it has cooled heat it in the double boiler over a low flame. (The water in the double boiler should be just barely boiling.) Gradually, the liquid will evaporate, and *milk sugar* will be left.

You may be able to brush or scrape the milk sugar into a container. What does it look like, taste like, smell like? Milk sugar is *lactose;* it helps you digest your food. Mixed in with the lactose are little white bits of *calcium* and *phosphorous,* elements which your body uses in building bone tissue.

Think about all the things in milk. Maybe you can now begin to understand why milk is sometimes called the "perfect" food ■

INVESTIGATION

What To Do with the Cream

You will need 1 cup of light cream. Leave it in the refrigerator for three or four days, then take it out and beat it with an eggbeater (or an electric beater). Use a deep bowl so the liquid won't splash.

How long is it before you begin to see little chunks of butter in the cream? As you continue beating, all the little chunks come together. How much butter do you get from a cup of cream? (Would you get the same results with heavy cream?) What does it taste like? Try it on a piece of toast. Why do you think store butter is yellower than yours?

Butter is fat and gives you energy. It contains vitamin A, which is important to your eyesight.

What about the liquid left over after the butter is made? Can you take it apart?

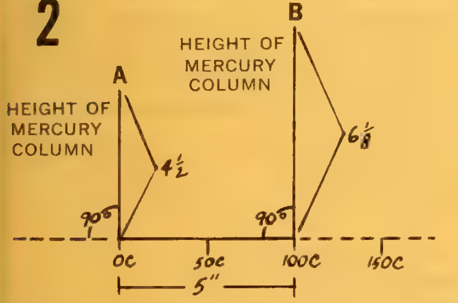
Using This Issue . . .

(Continued from page 2T)

and forces mercury up higher in the tube; when the gas is cooled, it contracts, exerting less pressure on the mercury. The mercury then drops lower in the tube. The level of the mercury is a measure of the pressure of the gas at a given temperature—also a measure of the kinetic energy (energy of motion) of the atoms and molecules comprising the gas *(see diagram on page 11)*.

You might draw a diagram of a gas thermometer on the chalkboard and explain how it works. To show how Kelvin arrived at the number –273.15, draw a diagram on the board, following the dimensions in Diagram 2 here.

2



Vertical line A represents the height of the mercury column in a gas thermometer when the gas is at the melting point of ice (0°C); vertical line B, the height of the mercury when the gas is at the boiling point of water (100°C). For each degree of temperature rise or drop, remember, the mercury rises or drops by the same amount.

Ask your pupils to predict how high the mercury would be raised if the gas were 50°C, 150°C, 200°C. Draw a straight line from point A through point B, and beyond. All three temperature changes fall on this line, the height of the 50°C line being determined by positioning the 50°C line exactly midway between points 0°C and 100°C. The height of the 150°C line, similarly, is determined by its position to the right of the 100°C line, and so on. Draw all three vertical lines (50°C, 150°C, and 200°C) on your chalkboard diagram.

Now ask your pupils what path the sloping line will follow at –50°C, –100°C, –150°C, –200°C, –250°C, –300°C. Plot these points on the base line at equal intervals. The sloping line will continue as a straight line and will intersect the base line at –273°C *(see diagram 3)*. Kelvin hypothesized that all molecular motion ceases at "absolute zero." The "energy line" AB shows the point on the temperature line (–273°C) at which this should occur.

If your pupils protest that a gas becomes a liquid before the temperature reaches –273°C, they are right. No one knows for sure what molecules do at absolute zero; that temperature has never been reached.

Activities

Extremely low temperatures can be produced only in a laboratory, and substances at those temperatures are too dangerous for children to work with. However, with reasonable care, you can safely demonstrate in your classroom some of the effects of low temperatures on common materials.

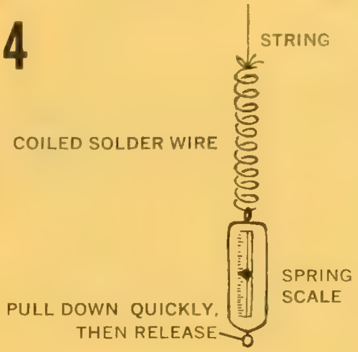
You will need about 12 ounces of dry ice (which you can order through a local ice cream dealer), 6 or 8 ounces of acetone (from a pharmacist or your high school chemistry teacher), a mixing beaker or a large fruit juice can, a heavy cloth or towel, a hammer, gloves, tongs or a kitchen spoon with wood or plastic handle, some pliable materials (rubber bands, wire solder from your school custodian, a frankfurter, a flower), and some newspaper to cover your demonstration table.

Do not handle the dry ice with your bare hands. Wear gloves and use tongs or the mixing spoon.

Wrap about 4 ounces of dry ice in the heavy cloth and use the hammer to break the ice into small pieces. Pour about 2 ounces of acetone into the can and gradually add the dry ice. The acetone will bubble violently at first but it will gradually stop as it gets colder. When it has stopped bubbling, add enough dry ice to make a slush. In this way you should be able to produce temperatures of about –100°F.

With the tongs or spoon, put a few rubber bands into the slush and let them remain for several minutes. Take them out and tap them with the hammer. These usually elastic objects will be hard and brittle. Do the same with the frankfurter. A small flower dipped in the mixture will freeze immediately. When removed, it will be so brittle that a slight squeeze will shatter it.

4

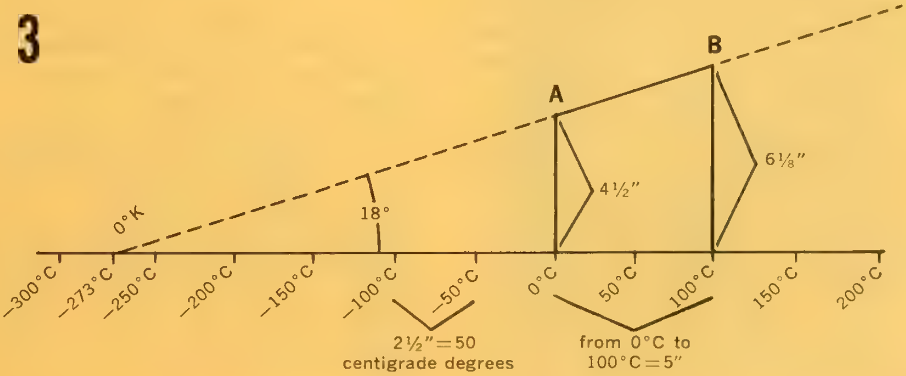


Take two lengths of solder wire, each 2 feet long, and coil each of them around a test tube or other cylinder about the same diameter. Wind the coils as close together as possible.

Bend the ends of each coil into hooks, and tie a string to one end of each coil *(see diagram 4)*. Place one coil in the dry ice slush. While it is cooling, hold the other coil by the string and hook a spring scale or small weight to the lower hook of the coil. A quick pull downward on the scale or weight will leave the coil extended. See if your pupils can predict what the other coil will do when you lift it from the slush, suspend the scale from it, and give the scale a quick pull downward. The frozen coil should recoil to some degree.

To dispose of the cold slush, let it stand in the container overnight. It will gradually reach room temperature and can then be discarded.

3



N&S REVIEWS...
(Continued from page 1T)

it so. Both of the books should be in the junior high library.

Light You Cannot See, on the other hand, is not just an expansion of a couple of textbook chapters. It is a fresh idea. And it can be read in grades 4-7, as the jacket flap says. Here is a well-written, fun-to-read book that covers many subjects from infrared and ultraviolet to cosmic rays, with several stops in between.

Technology

Books such as **The Picture Book of Oil,** by Anita Brooks (John Day, 93 pp., $3.29) and **The First Book of Salt,** by Olive Burt (Watts, 62 pp., $2.65) might very well be considered social studies books, but there is a great deal of earth science in them. Both of the volumes are well-written and complete. They tell of how oil or salt was formed, how they are collected and processed, and what their uses are, as well as the history of man's search for these resources.

Eugene Kohn (son of Bernice Kohn, who wrote *Light You Cannot See,* above) was 14 when he wrote **Photography: A Manual for Shutterbugs** (Prentice-Hall, 61 pp., $3.50). Perhaps this is why the book is so good. To begin with, it is informatively written. In addition, it answers the questions that the upper elementary and junior high school student would ask about the subject, and tells the history of the camera, how it works, how to take, develop, and print pictures, and how to use trick photography. A charming book.

Teachers might be tempted to buy the following two books to help them answer pupils' questions: **The New World of Computers,** by Alfred Lewis (Dodd, Mead, 77 pp., $3) and **Miracle Plastics,** by Ellsworth Newcomb and Hugh Kenny (Putnam, 153 pp., $3.50). They will serve admirably for this purpose, but can also be used as recreational reading by teachers and pupils. Both are written in a sprightly way, and present the subjects thoroughly and in a manner that helps the reader not only to learn about the subject, but also to appreciate the importance of these technological developments for the man in the street. Both books can be used profitably by the upper elementary and junior high school pupils.

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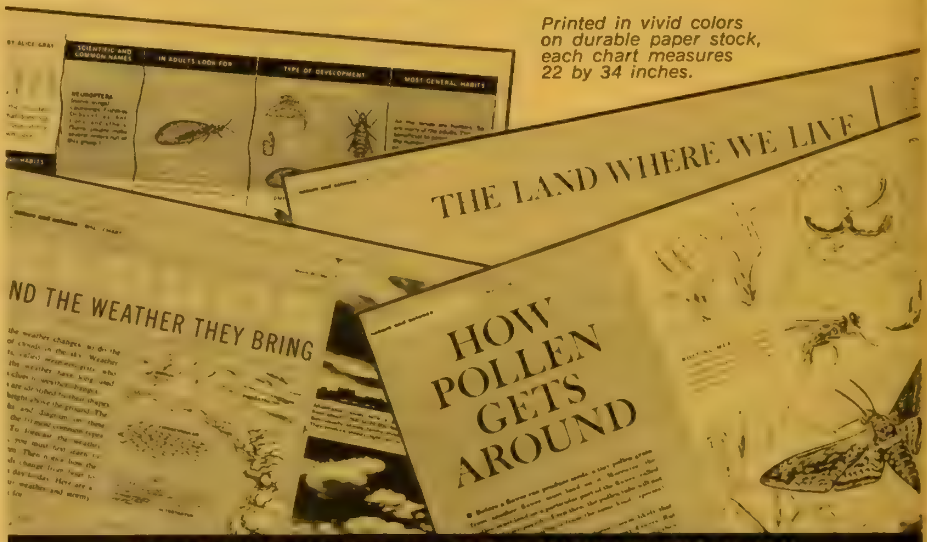
The Web of Pond Life (210)	Cross section of pond shows forms of plants, the feeding habits of pond animals.



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nature and science
TEACHER'S EDITION
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Do You Know as Much as Your Pupils Know about Today's World?

by Margaret Mead

■ The speed of developments in modern science has done something new and unprecedented to the relationship between teachers and pupils. Ever since we invented the kind of education in which the children of non-literate people were taught by the more literate, it has meant that some children—sometimes many children—knew more than their parents. This was particularly true in the United States, where so many unlettered young people immigrated as adults and their children rapidly became more at home, better educated, and better oriented than their parents. But always there were some adults who knew more than any children, including their own.

In the post-Sputnik world of the Second Scientific Revolution this is no longer so. There are now children who know more than any adult. This has become a truism at the university level where students in the sciences are continually outstripping their professors. But it has not been so widely recognized that this is also true in the homes of the young scientists who are doing the outstripping, and in the elementary schools, where teachers, reared in an earlier period, confront children reared in the modern world.

Is the Sky "Up" or "Out"?

People come away from Science Fairs shaking their heads over what individual youngsters have done, but still inclined to put it all down to something mysterious called genius. Very few teachers stop to consider what it means that nursery school children are drawing pictures of rockets in which the numbers read 10, 7, 8, 5, 6—the mistakes following the *count down* line instead of the old *counting out line,* when their tongues stumbled over the numbers from 1 to 10.

Very few teachers realize that it is still a conscious effort for them to remember how many and which satellites are orbiting the earth, while the children are so aware of them that their drawings of outer space, filled with first stages as well as satellites themselves, look as if outer space was already overcrowded.

To the adults, teachers as well as parents, the sky is still *up,* instead of *out,* and we bring our astronauts *down,* instead of *in* from orbit.

The adults still view computers as some kind of monster, essentially inexplicable even though one may understand the mathematics involved—a monster that may in fact take charge of our lives. Even great scientists like Fred Hoyle, when they write fiction about science, picture the kind of scientific mind that would be utterly shattered by having to think in a completely new way. And economists still argue about the problems of factory labor, blissfully unaware that modern technology will make factory labor obsolete and our problem will become, not production, but how to distribute the fruits of our productivity in an equitable and meaningful manner.

The modern scientific revolution has affected every aspect of our lives and the children know these new things, as the children of immigrants were familiar almost from birth with things with which their parents had had no childhood familiarity (street cars and telephones were as strange to them as TV and communication satellites are to us). The children know these things, not because they have

(Continued on page 4T)

Dr. Margaret Mead is Curator of Ethnology at The American Museum of Natural History.

IN THIS ISSUE

(For classroom use of articles preceded by ●, see pages 2T and 3T.)

● **Life Comes to a New Island**
A new volcanic island in the Atlantic offers scientists an opportunity to discover how land plants and animals cross a water barrier.

● **How Hot Can It Get?**
What happens to a substance as more and more heat is added to it.

Go on a Bird Nest Hunt
Most birds abandon their nests; your pupils can then collect and identify nests and learn how birds build them.

● **How Birds Cradle Their Young**
For a species of bird to survive, it must warm its eggs and protect its young. THIS WALL CHART shows how nesting has evolved to meet this need.

Make Your Own Microscope
How to build a handy, inexpensive microscope from materials around the house or school.

● **Secrets of the Swift**
How an ornithologist found out about the food, nesting, and breeding of a common but little-known bird, the chimney swift.

IN THE NEXT ISSUE

Man under the sea: an eyewitness account of Sealab... Waves and how they work...The food chain in the oceans... How man is learning about the canyons, mountains, and plains of the ocean floor...The deadly world of sharks.

USING THIS ISSUE OF NATURE AND SCIENCE IN YOUR CLASSROOM

PAGE 2 Island Life

Islands are excellent living laboratories and have long fascinated scientists. Darwin gathered some of his most convincing evidence for his theory of evolution on the Galapagos Islands off Ecuador. Past articles in *N&S* have reported on studies that couldn't have been achieved in a mainland environment *(see "My Three Years Among Timber Wolves," Jan. 24, 1964, and "The Case of the Vanishing Iguanas," Sept. 21, 1964.)*

When a new island forms, it offers opportunities for the study of *biogeography,* the study of the geographical distribution of plants and animals. You can help your pupils gain some understanding of this science through the following discussion questions.

Topics for Class Discussion

- *The ocean is a barrier for plants and animals that might live on Surtsey. Are there other kinds of barriers besides water?* A barrier can be many things—a desert, a mountain range, a grassland, a forest. Each can be a barrier to a plant or animal that is not adapted to that particular environment. The Grand Canyon is a barrier; there are different species of squirrels (evolved from a common ancestor) living on opposite sides.
- *Surtsey is only a few miles from other islands. What if it were 100 miles from the nearest land? How would this affect the rate at which life reached the island?* A barrier acts as a sort of filter, keeping back those plants and animals that cannot survive the environment of the barrier. A much larger barrier would slow down or filter out completely many kinds of plants and animals. Surtsey would then be colonized more slowly, probably with less variety of life.
- *How has man affected the distribution of life in the world?* He has circumvented all the major barriers, carrying a variety of life—from viruses to rats—with him. The remaining major barrier is outer space. Scientists are attempting to sterilize space probes to the moon and Mars so that we can learn something about their environments before being contaminated by life from the earth.
- *What kinds of barriers are there in your area? How do they restrict the spread of plants and animals?* There may be some small barriers, such as the water separating an island from the edge of a pond; this probably doesn't restrict any form of life from eventually reaching the island. A fenced-off, wide expressway, however, might be an effective barrier to animals like squirrels. There may be more effective barriers nearby, such as a wide river, a high mountain range, or the like. Have your pupils think of different kinds of plants and animals (such as dandelions and fish), then judge how a particular barrier would affect their distribution.

PAGE 5 How Hot?

This is the last of three articles exploring heat and cold. Part 2, in the last issue, explained the concept of absolute zero as the temperature at which an atom is in a state of complete rest, that is, motionless. Part 3 tells what happens to the atoms of a substance as more and more heat energy is added to it, and explains that an "upper limit" to temperature can only be imagined in terms of what we presently know about atoms and the particles that make them up.

Suggestions for Classroom Use

A simple classroom investigation can help your pupils understand how adding heat raises the temperature of a substance. You will need a beaker (or a tin can with edges flattened to prevent cuts), a measuring cup, a laboratory thermometer (temperature range: −10°C to 110°C), a heat source (alcohol lamp or electric hot plate), ice cubes, water, something to stir with.

Pour 4 ounces of water at room temperature into the beaker. Have your pupils measure the temperature of the water, then place the beaker over heat (*low* heat on the hot plate) and record the temperature of the water after one minute, two minutes, three minutes. If the heat source is fairly stable, it should add about the same amount of heat energy to the water during each minute, raising the temperature of the water the same number of degrees each minute.

Ask your pupils what would happen if you added the same amount of heat to twice as much water. Then repeat the investigation, using 8 ounces of water this time. If all conditions are the same except the amount of water, the temperature should rise only half as many degrees. Can your pupils explain why? Eight ounces of water is made up of twice as many atoms as 4 ounces of water. Therefore, each atom in the larger "bundle" gets only half as much heat energy, and increases its speed only half as much as each atom in the smaller "bundle."

Next, put some ice cubes and water into a fresh beaker and stir until the water temperature drops to 0°C. Position the thermometer bulb so that it is completely surrounded by ice. Place the beaker over the heat source and stir constantly. The temperature will not rise above 0°C so long as there is any ice left.

Can your pupils explain why the temperature does not go up even though heat is being added? The reason: The heat energy being added to the ice and water must first melt the ice before it can raise the temperature of the water.

The atoms of a solid substance are all vibrating, but they are held in a stable pattern *(see Diagram 1 at the bottom of page 5)* by bonding energy. Adding heat to the atoms makes them vibrate faster, raising the temperature of the substance and tending to weaken

(Continued on page 3T)

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nature and science

VOL. 3 NO. 6 / DECEMBER 6, 1965

a scientist
and some boys and girls
unraveled the . . .

SECRETS OF THE SWIFT

see page 13

THE BIRTH OF AN ISLAND

see page 2

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Lif

A volcano has risen from the Atlantic Ocean near Iceland, giving scientists a rare chance to discover how life invades a barren island.

■ We live on the North American continent—a land of r
coons, moose, cornfields, and many other living things.
we think of the rest of the world, we picture Africa with
giraffes, umbrella trees, and zebras; Asia with its Beng
tigers and bamboos; Australia with its eucalyptus trees a
kangaroos.

But how about islands? Suppose we were on an isla
in the middle of the Atlantic. What kind of life would
see? Spiders? Rats? Fir trees?

If we did see any of these, how would they have gott
there? Would some have arrived first, others later? Ho
could we ever know? The best way, of course, would be
build a new island, from scratch. We could then send
observer who would note, from month to month, exact
what was happening.

Now, there *is* a new island. It's in the North Atlanti
near Iceland *(see map)*. It's been there since 1963. A
there has been an observer visiting it every so often—
Icelandic geologist named Sigurdur Thorarinsson. Th
is our chance to find out how life comes to an island.

An Island Is Born

Early one morning, in November 1963, the fishing bo
Isleifur II lay some 20 miles off the southeast coast
Iceland. A seaman standing watch saw a red glow and
steamy cloud in the distance. He thought another sh
might be on fire, so he woke his captain, who got in touc
by radio with the Icelandic Coast Guard. The Coast Gua
knew nothing of any ship in trouble. As the *Isleifur*
moved closer to the rising smoke, the men on boa
realized that they were nearing an undersea volcano.

Thorarinsson, the geologist, arrived by plane with
three hours, and watched the steam and burning lava eru
from the sea. The following day he saw that a ridge
black land—the crown of a rising volcano—had risen abo
the water. Inch by inch, the island kept growing. Since th

Comes to a New Island

Howard L. Lewis

thical Norse god who had brought fire to Iceland was ned Surtur, the Icelandic government decided to call new island Surtur's Island, or *Surtsey*.

e Comes to Surtsey

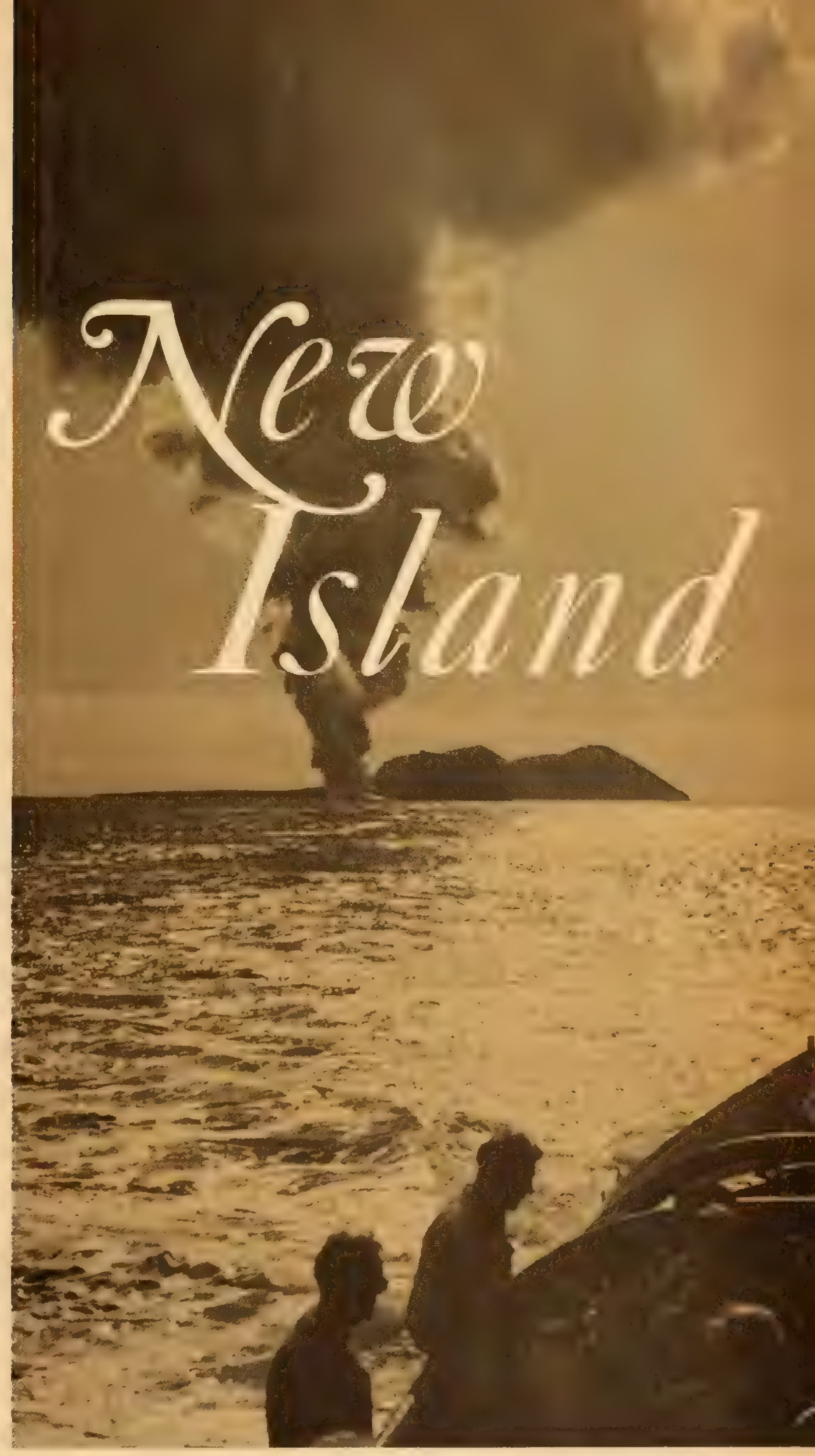
At its birth, in the last weeks of 1963, the island of tsey was barren and sterile; there were no living things it. It was probably much like the primitive earth in the g ages before life emerged from the sea. For this reason, tsey's rocks alone may be valuable clues in the study he age of the earth and its composition. Also, by observ- life on Surtsey over many years, scientists may learn nething about *ecology*—the study of how living things end on each other and on their surroundings.

Surtsey is an outdoor, living laboratory. It is shaped a circle about one mile wide *(see photo on page 4)*. active crater pours hot lava (molten rock) down the es of a 600-foot cone. Cooled lava covers about one- d of the island. In one area, a large lava lake has med—constantly fed through a tube-like hole that ches down through the earth's crust beneath the ocean. e remainder of the island's surface is covered with vol- ic ash.

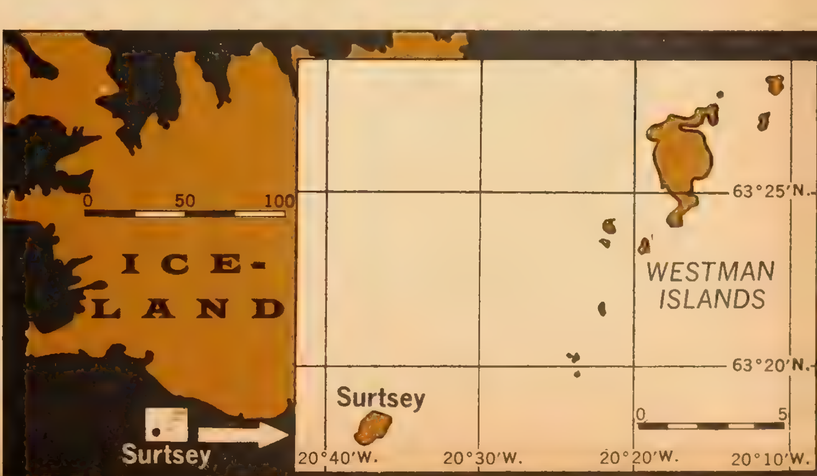
The invasion of Surtsey by plants and animals has eady started. As seen from an airplane, Surtsey is begin- g to take on a greenish tint—the first forms of plant are beginning to take hold. Seeds, spores, and small mal life are being air-lifted to Surtsey by birds and winds l washed onto the island's shores by the sea. There are ny islands not far from Surtsey, and it is from these that st of Surtsey's new plants and animals will come.

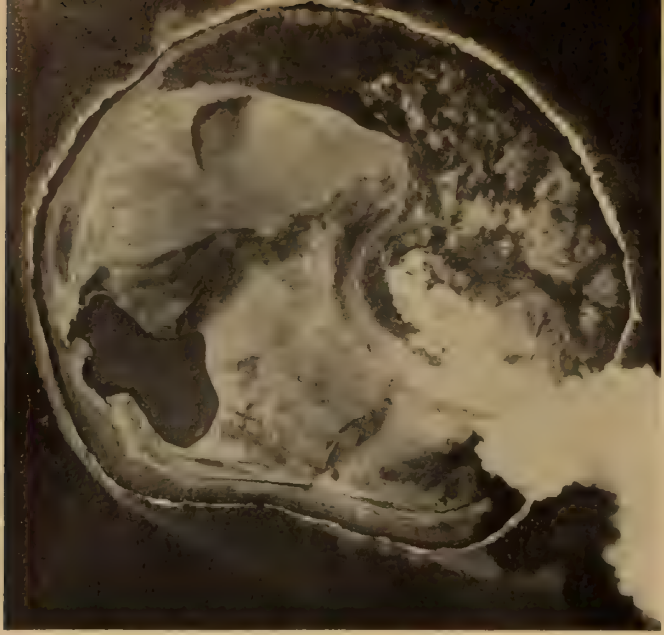
The settling of the island is fascinating to watch, because one knows exactly what will happen. Some kinds of nts and animals, of course, could never reach Surtsey survive there. Still, scientists cannot say for sure what

(Continued on the next page)



Scientists land on the new island regularly to see how it has changed and what new forms of life have reached it.





You can see the lava lake and the smoking volcano cone in this photo taken from an airplane directly over Surtsey.

Life Comes to a New Island (continued)

will happen. As they watch Surtsey, they also think of another part of the world—Indonesia—where another "new born" island has been studied.

How Life Came to Krakatoa

Indonesia is one of the world's most active volcanic regions, with volcanic craters marking the map like measles. For centuries, navigators sailing through the Strait of Sunda (between the islands of Java and Sumatra) took one of its volcanic islands—Krakatoa—as their landmark. Its high volcanic cone could be seen for miles.

One day, in 1883, the island exploded in a series of eruptions that left only the edges of a 2,600-foot cone. The island was believed to have been completely sterilized, with all forms of life destroyed by heat.

Just nine months after the eruption, a scientist examined Krakatoa. The only life he found was one lone spider. There it was—spinning a web for prey that probably didn't exist. But scientists believed that life would come back to the island quickly—most of it from Sumatra and Java, 25 miles away. Their predictions came true.

Within three years, 11 different kinds of ferns and 15 flowering plants had returned to Krakatoa. Seeds, spores, and fruits—carried by winds, ocean currents, birds and other animals—were the first colonizers of Krakatoa. One type of plant seed was so shaped that it could hook onto the feather of a bird. The spores of ferns are so light that they can be carried hundreds of miles by the wind. More than half of the island's plants just drifted ashore. The coconut, for example, is easily spread by water. Its hard, wax-covered shell is ideally suited for journeys at sea.

A layer of green growth had covered Krakatoa in another 10 years. It included young coconut trees, wild sugar cane, and four kinds of orchids. A quarter century after Krakatoa's eruption, 263 species of animals, mostly insects, had managed to reach the island. There were 16 kinds of birds, two species of reptiles, and four species of land snails. In only 50 years after Krakatoa had become a sterile land—without any plant or animal life—it had regained most of the kinds of plant and animal life that lived there before.

The Future of Surtsey

The scientists of the 1960s and 1970s will be watching Surtsey. Within a week of its "birth," a group of newspaper photographers from France went ashore. They were greeted with a volcanic eruption and were lucky to escape with their lives. In mid-December 1963, the first scientists went ashore. And a year later they reported that life was coming to Surtsey much as it had to Krakatoa.

A live mussel (a kind of clam) and a moth have been found. Grass, rush seeds, leaves, flower stalks, and some rooted plants have been washed ashore, but they are not yet flourishing. Some bacteria and molds now grow on the island. They were probably carried there by wind currents or airlifted by visiting gulls, other sea birds, and wandering land birds. Seaweed and green algae have taken hold at Surtsey. All of this life reached Surtsey less than one year after the island emerged from the ocean.

Scientists from the United States and Iceland—including Dr. Thorarinsson—are now cooperating in the study of Surtsey. They make at least one visit every two weeks to the new island. Nearby islands and coasts are also being studied, for it is these islands that will contribute most of Surtsey's new life.

The scientists studying Surtsey have much better equipment and methods available than the men who first studied Krakatoa. Machines can now automatically record the land and sea temperatures. Airplanes equipped with mapping cameras are used to make almost weekly maps of the new island to chart its growth. Special x-ray equipment can record the exact age of Surtsey's rocks, what minerals they are made of, and how the particles are arranged.

As the studies of Surtsey began, another exciting possibility turned up. The photo on the cover shows two scientists on Surtsey watching another volcanic cone coming up from the sea, about a quarter of a mile away. The new island may endure and also become a permanent part of the North Atlantic map. If it does, scientists will have available two living laboratories—side by side—in which to study how life comes to a new island ■

EXPLORING HEAT AND COLD

PART THREE

HOW HOT CAN IT GET?

by Roy A. Gallant

Who ever heard of a boiling fireplace poker...or a teaspoon of gas 10 times heavier than a teaspoon of lead? The world of high temperatures is a strange one.

■ What is the hottest thing you can think of? A glowing coal? The liquid rock inside a volcano? The sun? Can you guess the temperature of these things?

When you read "How To Make a Thermometer," the first article in this series, you found that temperature is a measure of how fast the atoms making up a substance are moving around. When you heat up a piece of iron, for example, you are adding energy to the atoms of the iron, making them jiggle around faster. The faster its atoms move, the higher the temperature of the piece of iron.

Going Up!

Imagine that you are holding an iron poker in the flame of a wood fire. Let's find out what happens to it as we raise the temperature of the poker. The high-speed atoms of the flame bump into the slower atoms of the poker. As the atoms at the end of the poker begin to vibrate faster and faster, they jar neighboring atoms farther along the poker. These, in turn, make their cooler neighbors vibrate faster, and so on along the poker to its handle. Soon, the rapidly vibrating atoms of the handle speed up the motion of atoms in your hand—and your hand feels hot.

Gradually, the poker becomes so hot that you have to put it down. Suppose that our fire is hot enough so that we can keep on adding heat to the poker, speeding up its atoms more and more. After a while, the poker would glow a dull red; eventually, the hot end would droop. Its atoms are now vibrating so fast that they overcome the forces holding them together, and the atoms begin to slip and slide over each other. When the atoms do this, the iron is beginning to melt. We have heated it to 2,786°F, its melting point.

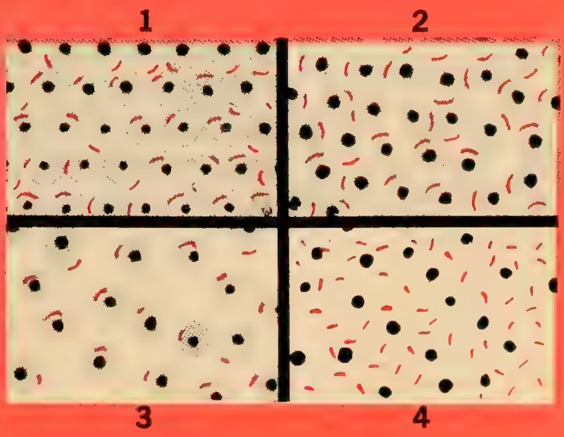
Suppose now that we let the melting iron drip into a special pot, then add still more heat. What will happen? As the liquid iron continues to take up heat, its atoms move about still faster, slipping and sliding over each other with even greater ease. When the temperature reaches 5,432°F, the atoms at and near the soupy surface are dashing about so fast that they begin to fly off into the air. They continue to fly off until there is no more iron in the pot.

Like water left to boil away on the stove, the liquid iron has boiled away, or *vaporized*. In other words, the iron that was once a solid poker has become a gas. In a laboratory, we could go on heating the iron gas to even higher temperatures. The question now is, "how high a temperature?" In fact, is there a "highest possible" temperature? The stars can help us explore this question.

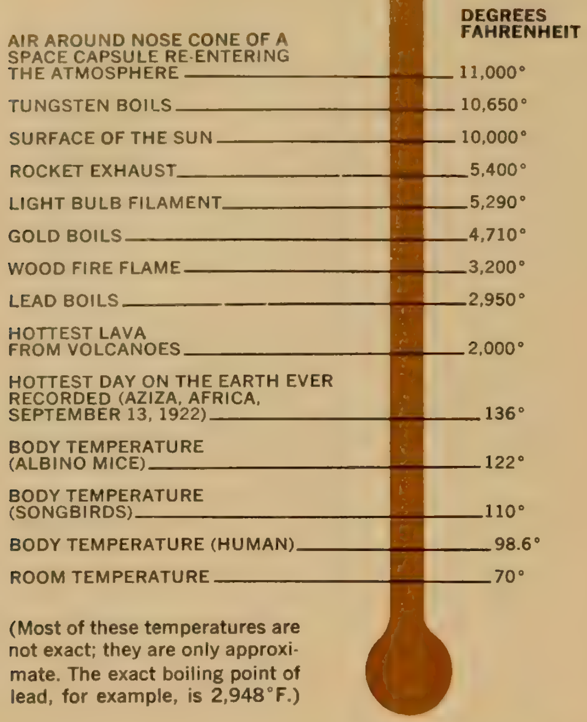
(Continued on the next page)

What Happens to the Atoms of a Solid Substance as Their Temperature Is Raised

1. At room temperature the atoms are firmly "frozen" in a pattern **2.** As the temperature of the solid is raised to its melting point, the solid becomes a liquid, and its atoms slip and slide over each other, breaking the pattern. **3.** When the boiling point of the solid is reached, the atoms break apart from each other and become a gas. **4.** As the temperature of gas is raised, the atoms themselves begin to break apart and form a "plasma." (The short colored dashes are electrons; the black dots are the nuclei of the atoms.)



HOW HOT IS IT?



(Most of these temperatures are not exact; they are only approximate. The exact boiling point of lead, for example, is 2,948°F.)

Does High Temperature Always Mean Lots of Heat?

If you took a trip up through the earth's atmosphere, you would be in for a surprise. For the first few miles up, the temperature would fall lower and lower—down to about —70°F at a height of about 10 miles. But at 90 miles or so, the temperature is about 1,000°F. Yet, if you stepped out into the very thin air at that altitude without a heated suit, you would freeze to death! How can that be? How can we have such a high temperature with practically no heat?

To have more heat, we must have lots of atoms darting about. At a height of 90 miles, the atoms making up the very thin air are zipping around extremely fast—which accounts for their high temperature. But there are not *enough* atoms at a height of 90 miles to heat you. You would freeze to death. If the atoms of air at the earth's surface were darting about as fast as the air atoms 90 miles up, we would all bake to death. Not only would there be an extremely high temperature; there would also be lots of heat.

Suppose that you fill a bathtub with hot water, then dip out some of the water with a glass. Although the temperature of the water in the glass is exactly the same as that of the water in the tub, the tub contains *more* heat than the glass. The reason is simple: There is more water in the tub to contain heat. If a glassful of water contained the same amount of heat as a tubful of water, would the temperature of the water in the two containers be different? Which would be higher?

Heating the Stars

Many years ago, scientists thought that the stars were flaming torches in the sky. Today we know that the sun and other stars cannot give off heat, light, x-rays, and other forms of energy by *burning,* as a fire does. Something special must be happening inside the stars, something that does not happen naturally on the earth.

The great amounts of gases in a star are packed very tightly, and their atoms are moving about so energetically that they are smashing into each other with tremendous force. They batter each other so hard that they break apart. As a result, the stars are composed of bits and pieces of atoms. This kind of gas is called a *plasma.* It may surprise you to learn that nearly all of the matter in the universe is plasma. The whole atoms that make up your body and the chair you are sitting on are exceptions, not the rule.

Even though the sun is plasma, its bits and pieces of atoms are packed so tightly together that a teaspoon of the sun's core weighs about 10 times more than a teaspoon of lead. So much matter packed into so little space means that the sun's deep-inside temperature must be very high; it is about 11,000,000°K. (You'll remember from "How Cold Can It Get?" that K stands for degrees Kelvin.) It also means that there must be enormous amounts of heat in the sun.

How Hot Can It Get?

Does the center of the sun have the highest temperature we know of? No. There are many stars whose hot cores have temperatures as high as 100 million degrees K. These are the highest *natural* temperatures *we know of.* But that does not mean that there cannot be still higher temperatures somewhere in the universe.

In a hydrogen bomb explosion, for a small fraction of a second the temperature is about a billion degrees K. Is it possible to go higher still? Yes. What we know about atoms today lets us imagine a temperature of 10,000,000,000,000°K–10 thousand billion degrees! At that temperature, scientists think that the pieces of atoms that make up plasma would themselves be broken up into even smaller pieces. But so far, no one has produced such a high temperature. The same thing is true of absolute zero. We can imagine a temperature that low, but no one has reached it.

By the time you are in college, scientists may have learned more than we now know about atoms and the particles they are made of. Perhaps then it will be possible to imagine temperatures higher than 10,000,000,000,000°K and lower than O°K. But right now, we can't imagine anything getting hotter or colder than that ■

Go on a Bird Nest Hunt

by Laurence Pringle

■ Bird nests are cradles, not homes. Few kinds of birds use their nests over again.

You can easily find these abandoned nests in the fall and winter when the leaves have fallen from most trees and shrubs. Each nest you find presents a mystery: What bird built it? You can probably identify many of them, for each kind *(species)* of bird builds a particular kind of nest *(see pages 8 and 9)*. By looking at nests you can discover how birds build them.

Taking Nests Apart

Since most nests are built within six to eight feet of the ground, you will find many nests in young trees and bushes. When you discover a nest, first jot down some notes on its location. Is it in a marsh, a meadow, or a woods? Is it hidden in grass or leaves on the ground? Is it three feet up in an evergreen, or hanging from the branches of an elm? Next, look at the nest itself. Note its shape and measure its width and depth.

To find out what a nest is made of, take it apart, bit by bit. Make separate piles of the different materials on a sheet of newspaper or white cloth. You may find twigs, small roots, leaves, bark, moss, mud, grass, hair, and feathers. There may be some man-made materials, such as paper, string, and tinfoil. Count the number of pieces of different material. How many flights do you think the bird (or pair of birds) made to gather the nesting material?

Do you think you could put the nest back together again? Try it and see how well you do.

The materials you find in nests are important clues that will help you identify the bird that built the nest. The books listed below will also help. Robin nests, for example, have walls of mud, lined with grass. The nests of goldfinches are lined with thistledown, a soft, white material from the flower of a thistle plant.

Birds vary their nests somewhat with the materials available. The crested flycatcher, which nests in hollow trees, usually weaves a castoff snakeskin into its nest. If no snakeskin can be found, the flycatcher uses a piece of cellophane, such as a cigar wrapper.

A few years ago I put some nesting materials in a garden, including yarn and some locks of hair left over when my baby sister was given a haircut at home. I saw an oriole take the yarn and weave it into its nest. But what bird took the fine baby hair? Weeks later I looked inside a birdhouse and found the delicate strands—lining the nest of a bluebird.

Next spring and summer, get some nesting materials from around your house—short pieces of string, yarn, some cotton, hair, and so on. You might try yarn of different colors to see if certain colors are preferred by birds. Put the nesting materials in a place where birds can find them; then watch to see what kinds of birds take the different materials. Later on, try to find the nesting material in abandoned nests ■

INVESTIGATION

A scientist in British Columbia found that the kind and amount of materials used in bird nests varies with the location of the nest. For example, he found that robins use more moss than usual when they build nests in particularly cold spots. You might investigate this idea by collecting several nests of one kind of bird, such as the robin. Keep careful notes on the location of the nests and then take them apart. Compare the kinds and amounts of different materials used in the nests. Then see if you can explain the differences by looking at your notes on the nests' location. Was the nest built where the usual nesting materials are scarce? In a particularly windy spot?

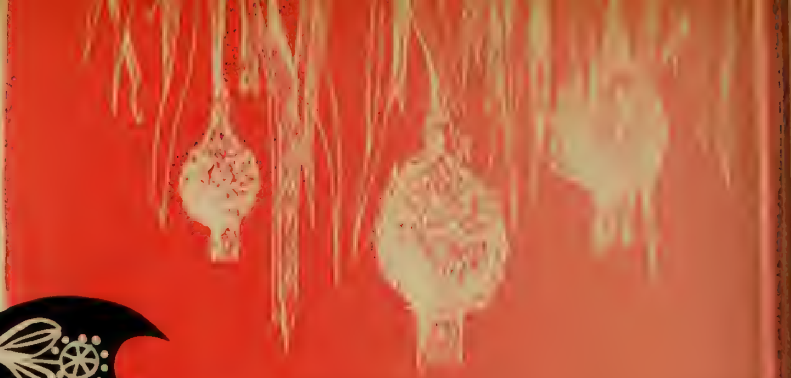
For more information about bird nests and how to identify them, see these books: **Birds' Nests,** by Richard Headstrom, Ives Washburn, Inc., New York, 1941, $4.25; **Birds,** by Herbert Zim and Ira Gabrielson, Golden Press, New York, 1956, $1 (paperbound); **Audubon Land Bird Guide** (1949), **Audubon Water Bird Guide** (1951), each $4.50, and **Audubon Western Bird Guide** (1957), $4.95, all by Richard Pough, Doubleday & Company, Inc., New York.

How Birds Cradle Their Young

■ About 150 million years ago, the first birds gradually developed, or *evolved*, from reptiles. Birds are still like their ancestors in some ways. For one thing, birds still lay eggs with shells. A few birds even *incubate*, or warm, their eggs the way that some reptiles do, by burying them in a mound of rotting vegetation *(see drawing)*.

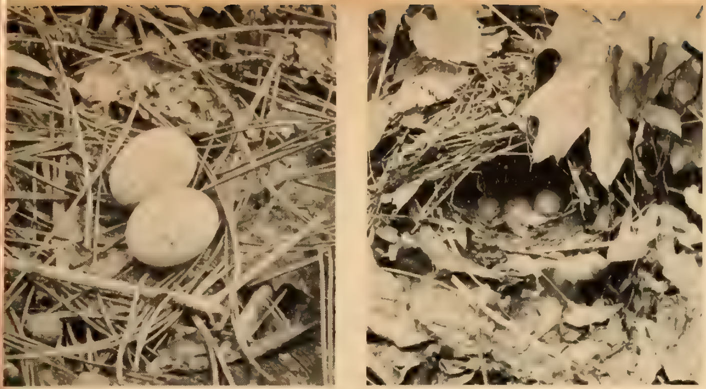
Since evolving from reptiles, however, birds have become *warm-blooded* animals, with a normal body temperature of about 105° to 111°F. Most birds now build nests in which they warm their eggs with their own body heat. The nests also serve to protect the eggs and young from storms and from animals that might eat them. Each of the 8,600 different kinds *(species)* of birds in the world has a nest that suits its needs.

The drawings and photos on these pages show some of the amazingly different kinds of bird nests. The captions tell something about how the nest is built and how its particular design helps the bird to raise its young ■

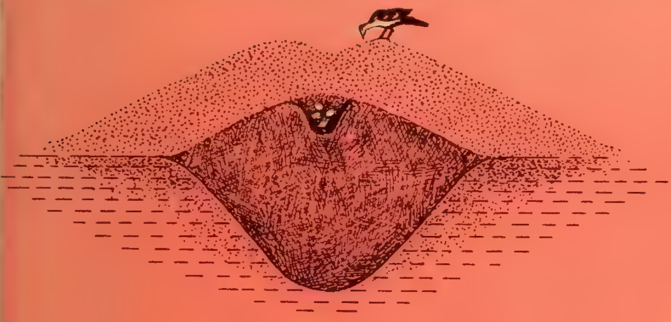


ORIOLES WEAVE a purse-like bag that hangs from the tips of slender branches (often in an elm). Even fancier weaving is done by the weaverbirds of Africa and southern Asia. Some of these weaverbirds actually tie knots with strands of grass. Some weaverbird nests have long entranceways hanging below the nest *(above)*. A partition inside the nest keeps the young from falling out.

TREE NESTS are safer than ground nests, but they present s
cial engineering problems. Some large birds, such as eagles
great blue herons *(above)* build nests that are used year a
year. New twigs and branches are added each year. One nes
a bald eagle was used for 36 years and weighed about two t
when it finally crashed to earth along with the tree which
held it.

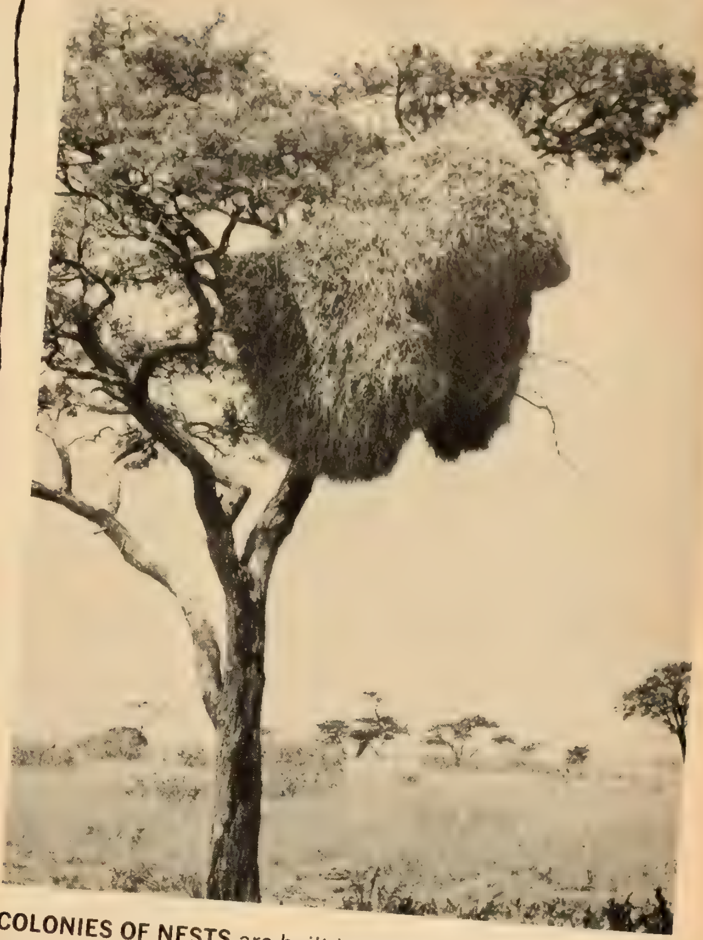


NESTS ON THE GROUND are not as safe as those in holes or in rees. The eggs and young of ground-nesting birds are protected n many different ways. The whippoorwill, for example, has no est at all. Its speckled eggs are laid on the forest floor *(left)* here they blend with the color of dead leaves. Other ground-esting birds build carefully hidden nests. An ovenbird's nest *right)* has a roof of leaves that helps hide the eggs and young.

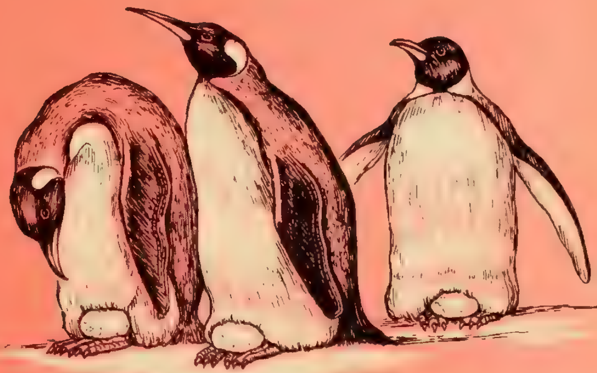


HE MALLEE FOWL of Australia warms its eggs in much the ame way as crocodiles and some other reptiles. The male bird iles up leaves and soil into a huge mound—sometimes 5 feet igh. In this mound the female lays about one egg a week for everal months. Heat from the rotting plant material keeps the ggs warm. The male tends the nest, adjusting a layer of sand ver the eggs so that the temperature stays near 92°F. When a oung mallee fowl hatches, it struggles up through the sand and ets off on its own.

HOLES IN TREES or in the ground are used by many different kinds of birds. Some nesting cavities are just natural holes; others are chipped out of trees *(right)* or dug in the ground. These holes offer safety and shelter, so birds often fight for the use of them. Birds that use these cavities often have simple nests inside. In fact, some birds whose ancestors built elaborate roofed nests now raise young on a simple pad of grass inside a tree hole.



COLONIES OF NESTS are built in places that offer special protection. This photo shows a spectacular bird "apartment house," built by the social weavers of Africa. As many as 100 pairs of weavers cooperate in building a roof of grass. Then each pair makes a separate nest under the roof. The nests are protected by the roof and by the thorns of the trees in which the nests are built. Most of the colony-nesting birds are seabirds, which nest on isolated islands or on cliffs.



NO NEST is built by the emperor penguin of the Antarctic. The male penguin holds a single egg between its feet and its body for more than two months. Several males usually huddle together, protecting their eggs from the below-zero cold of the Antarctic winter. When the egg hatches, the female returns to help feed the young penguin.

MAKE YOUR OWN MICROSCOPE

by Steven Morris

With the bulb from a pen flashlight and some everyday things, you can make a microscope that magnifies 80 times.

■ I saw a grasshopper in a spider web. He kicked strongly but he couldn't get out of it. The spider came closer.

The web was so thin that I had to look closely to see the single threads. I had read that there is a kind of glue on the threads that traps insects. Was it in the form of drops, or was it a smooth coating?

If I'd had my microscope I could have found out. But it was at home. I took some of the spider web home, but it got crushed on the way.

Later, I found out how to make a simple microscope that's small and light enough to take on trips, yet powerful enough to make things look 80 times bigger than they are. Most of the things you need (*see box*) to make a microscope like this are in most people's homes, so it may cost you as little as 20 cents (for a penlight bulb) to make one.

How To Make Your Microscope

Begin by sawing the piece of wood into four pieces (*see diagram for sizes*). Smooth the sides and ends with sandpaper so they will fit together tightly.

Next, drill holes of the proper size in the places shown by dotted lines in the diagram. Some of these holes will be where a screw or nail goes to hold two pieces together, so it's important to drill these holes in exactly the right place. To make sure the holes are right, hold the two pieces of wood together so you can drill both holes at once. Mark each piece of wood so that later on you'll be able to remember where the pieces are supposed to go.

If you don't have drill bits of the right size make the holes by hammering in nails that have the proper wideness.

Glue aluminum foil over the top of the one-inch-square block, and about ⅛ of an inch down each side. Be sure the foil is smooth so that it will reflect as much light as possible. (If you have a glass mirror that is small enough to be glued on the wood block, it will work even better.)

To hold the mirror block under the lens in your microscope, use a piece of coat-hanger wire. Cut a piece 4½ inches long, and bend it to the shape shown in the diagram. Push the bent end into the hole in the side of the block.

Now, using Duco cement or Elmer's glue, glue the wood blocks together as shown. Put in the nails and set the frame aside to dry.

While it is drying, you can bend two paper clips into slide holders (*see diagram*). Shape them with a pair of pliers, then screw the holders into place.

Next, glue the spool under the 7/32-inch hole through the top of the microscope frame so that you can see down through the hole in the frame and the hole in the spool. Paint the inside of the spool and hole with flat black paint. To make the lens holder, use your tin shears or old scissors to cut from your tin can lid—or from a piece of copper flashing—a strip 3¾ inches by ⅝ of an inch. Drill a neat 7/32-inch hole in one end, and file or scrape it smooth. Drive a nail through the opposite end to make the ⅛-inch screw hole. When driving the nail, lay the strip on a piece of wood that you don't need. This will help make the hole neat and keep you from damaging your work area. If you use plastic instead of metal for the strip, drill both holes slowly so you won't crack the plastic.

The lens at the tip of the penlight bulb is what we'll use

The microscope described in this article was designed by Gill Smith, a consultant to the Elementary Science Study project of Educational Services Incorporated.

for the microscope lens. To get this lens, you must first cut the metal base off the bulb, using the shears. *Be sure to cover the bulb with a piece of heavy cloth when you're cutting, to keep the pieces from flying across the room.* (Another way to cut off the base is with a screwdriver and a hammer. But there's more chance of splitting the lens this way.) Use pliers to break off tiny pieces of the bulb until you are within 1/16 of an inch from the lens.

To glue the lens into the hole in the strip, put a little Ambroid or Duco cement around the rough part of the lens and press it against the underside of the strip. The smooth dome of the lens will be sticking through the strip. Let the cement dry. Then paint a black rim around the domed side of the lens so light won't be able to come up around its sides. The paint should go a very little way up the sides of the dome to cut down glare from the side. Instead of paint, you can use black sticky tape with a hole cut in it.

Stick the straight end of the mirror holder into the hole in the frame as shown in the diagram. Then screw the lens holder onto the top piece of wood, with the lens right over the hole. Make sure the strip is flat against the wood. Also make sure there's no dirt, cement, or paint on the top or bottom of the lens. Use a Q-Tip, or a toothpick with cotton wrapped around the end, to clean the underside of the lens.

Using Your Microscope

If you want to look at something through your microscope, put the object on a glass slide or a strip of clear plastic about 1 by 3 inches, then put it under the lens. (The slide holders will hold the glass or plastic in place.)

Look through the lens. Rock your mirror back and forth. How does the picture change? Can you see clearly what you put on your slide? If not, you must move the lens to get a sharper picture. Lay a nail or thin piece of wood under the lens holder at about its middle. Now, while looking through the lens, move the nail or wood slowly toward the lens, then toward the opposite end of the strip. How does the picture change as you move the nail forward and backward? Move your eye closer to the lens, then farther away. How does the picture change?

Put a very thin slice of onion under the lens. Look at it. Now put a slightly thicker slice under the lens. Look again. Do you see it as clearly? Move the mirror mount. What happens? Raise and lower the lens. What happens?

You can take this little microscope with you on hikes and nature trips. If you come to a pool of water that looks perfectly clear, take a drop and put it under your lens. You may be amazed. In future issues, we will suggest some other ways that you can use a microscope to explore the world of very small things ■

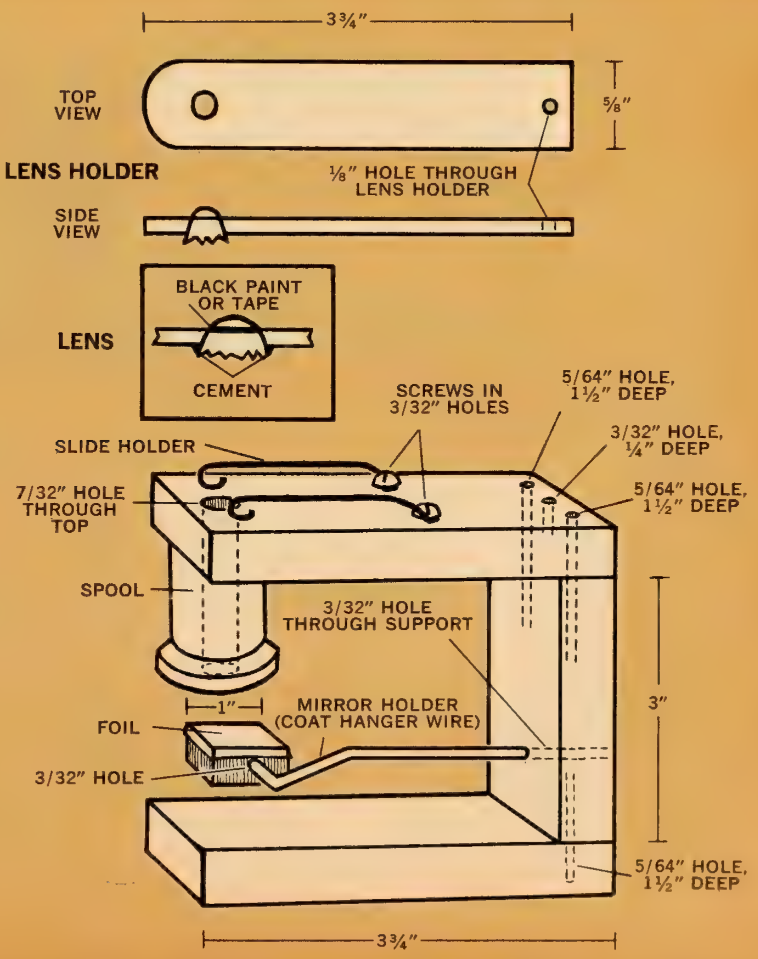
What you will need to make this Microscope

Materials

- Ambroid **or** Duco cement
- Weldwood Contact Cement **or** Elmer's Glue
- Large tin can lid **or** copper flashing **or** plastic strip
  1/16″ thick, 3¾″ long, and ⅝″ wide
- Wire coat hanger
- Orange crate wood (**or** other soft wood)
  11″ x 2″ x ½″
- Three anchor **or** wire nails 1½″ long
- Three round-head screws ⅜″ long
- Two paper clips
- Penlight bulb (#224, 222, 112, **or** 114)
- Small thread spool (**or** saw a large one in half)
- Flat black paint

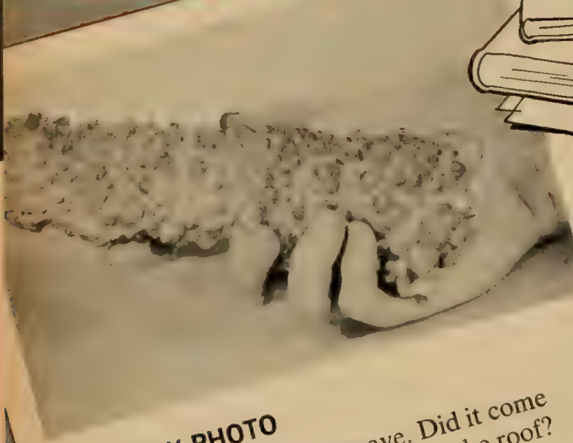
Tools

- Small saw
- Screwdriver
- Hammer
- Pliers
- Tin shears **or** strong, old scissors
- Hand drill **and** 7/32″, 5/64″, **and** 3/32″ drill bits
- Sandpaper
- Small piece of heavy cloth



prepared by **DAVID WEBSTER**

brain-boosters

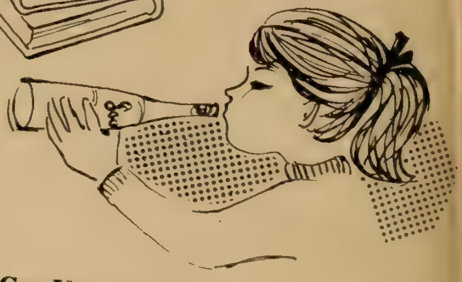


MYSTERY PHOTO

This rock was found in a cave. Did it come from the floor of the cave or from the roof?

Fun with Numbers and Shapes

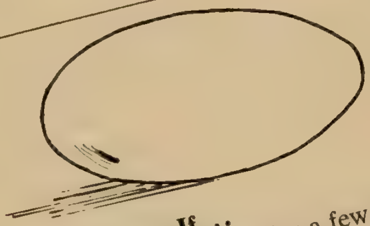
About how many words are there in this issue of *Nature and Science?* About 10,000? About 25,000? About 100,000? How can you find out without counting all the words?



Can You Do It?

Put a little wad of paper into the mouth of a soda bottle. Can you blow the paper into the bottle? (It looks easy, but it is really pretty hard.)

Submitted by Mike Threadgill, Fort Worth, Texas



What Would Happen If...

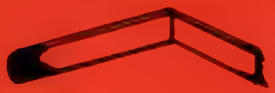
you soaked an egg in vinegar for a few days? Can you make the egg bounce a little?

For Science Experts Only

Since glass is smoother than ice, why couldn't you "ice skate" on a cold piece of thick glass? Or could you?

ANSWERS TO BRAIN-BOOSTERS IN THE LAST ISSUE

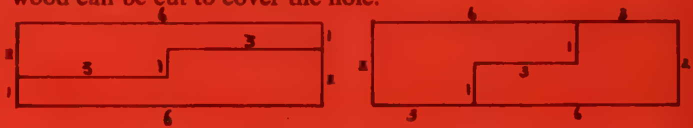
What Would Happen If...? The bigger ball takes longer to get to the bottom of the ramp.



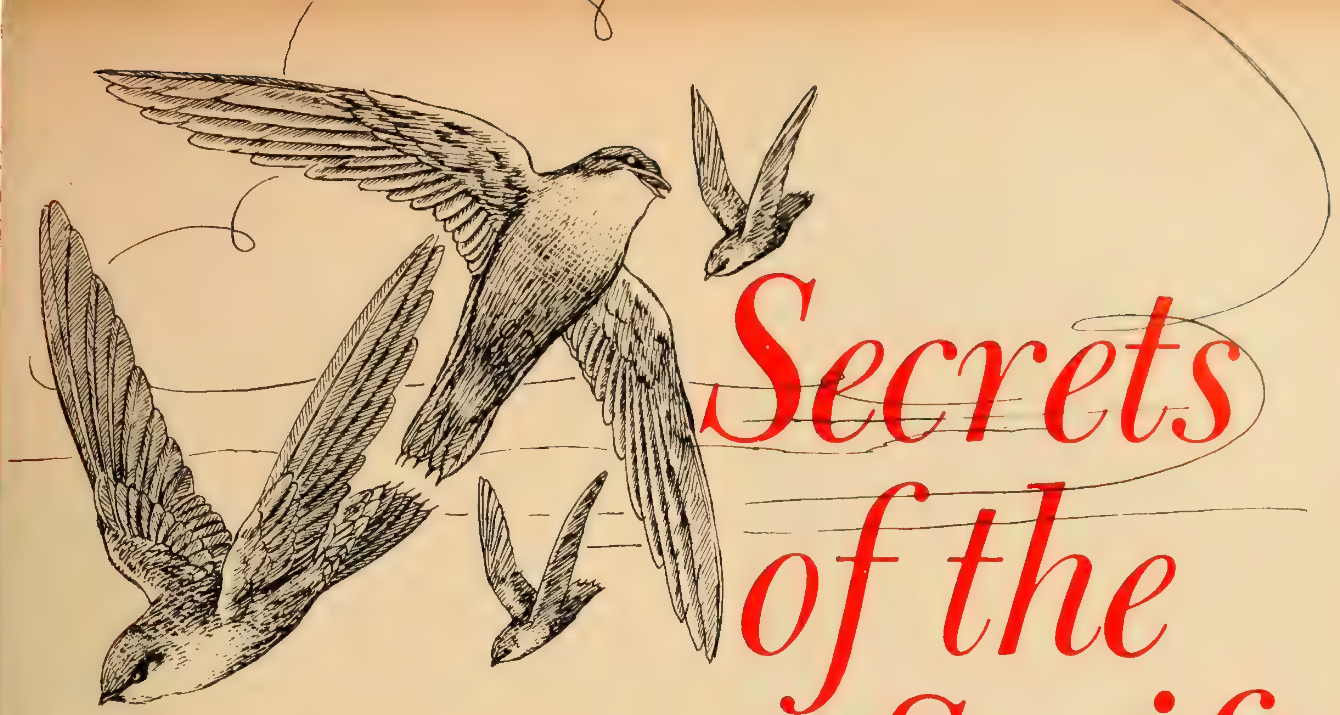
Can You Do It? To make a paper match land on its edge, just bend it a little before dropping it.

Mystery Photo: The smaller drop of water is more round and high for its width than the larger drop. Make some drops of different sizes yourself on a piece of wax paper or aluminum foil. Then look at them from the side. Are smaller drops rounder and higher?

Fun with Numbers and Shapes: The sketch shows how the wood can be cut to cover the hole.



For Science Experts Only: Denver is much higher above sea level than is Miami Beach. Because of this, the air in Denver is not quite as "thick." This would mean a golf ball would not be slowed down as much by the air in Denver and would travel a little farther. Also, since Denver is farther from the center of the earth than Miami Beach, the ball would travel slightly farther in Denver before the earth's gravity pulled it to the ground. The difference in distance, of course, is so slight that it could probably not be measured.



Secrets of the Swift

By Richard B. Fischer

There is still a lot to learn about animals that live right in your neighborhood. Here is how one man, helped by boys and girls, set out to investigate the life of a common but mysterious bird.

■ Of all the common birds in eastern North America, few are more cloaked in mystery than the chimney swift. It is an easy species to identify when it is zooming about our towns and cities (*see drawing*). But how can you observe a chimney swift when it is *not* flying? It doesn't perch on trees, posts, wires, roof tops, on the ground, or in any of the places where we usually see birds. Instead, the chimney swift rests inside chimneys, abandoned buildings, old woodpecker holes, hollow trees—even well shafts in the ground. When a swift drops into a resting place, he returns to a secret world where the most interesting events of his life unfold.

Nothing provokes an *ornithologist* (a scientist who studies birds) more than a bird that has secrets. I decided to find out just what does go on in our chimneys all summer long. From reading bird books, I already knew about the amazing stick-and-saliva nest that swifts fasten to the insides of chimneys, but I wanted to watch them build it. I also wanted to examine the eggs, record the growth of young birds, and discover what insects the swifts catch as they fly.

From books and science journals, I learned what was known—and unknown—about chimney swifts. The list of unanswered questions grew and grew. Soon I chose a research area where chimney swifts were common—a farming region in New York's Catskill Mountains—and set out to unveil the secrets of the swift.

Telling the Swifts Apart

Chimneys are fine homes for chimney swifts but they are impossible observation places for curious naturalists. You climb to a roof top and stare down the chimney and the birds do little more than stare back! They flee the chimney when you go away and it may be several hours before the timid birds venture back. No, chimneys would not do. I needed to find swifts that were not living in chimneys. Fortunately, swifts sometimes nest in places other than chimneys. By searching all the near-by barns, silos, and woodsheds, I found plenty of nesting swifts.

Next I had to devise a way to keep out of sight while watching the swifts. To do this I built hiding places (called *blinds*). The blinds were made of an odd assortment of old rugs, feed bags, and discarded canvas.

Chimney swifts are as alike as peas in a pod, yet I had to be able to tell one bird from another. To do this, I captured every bird I could and put a numbered metal band on one leg. With a powerful flashlight and an insect

(Continued on the next page)

Swifts cluster together when they roost at night, covering each other with their wings. These five swifts are clinging to a couch cover that hangs from a barn wall.

Secrets of the Swift (continued)

net, it was easy to catch the birds at night in their buildings.

Unfortunately, there is still no certain way to tell male chimney swifts from females by their looks. To determine a swift's sex, you have to kill it and examine the inside of its body. Nevertheless, it was important that I could tell the sex of living birds. Here is how I did it.

It turned out that many banded adults returned year after year to the study area. They sometimes paired with different mates in succeeding years. In a few years, I had worked out a sort of "family tree" of the local swifts. If I could determine the sex of just one banded bird, I could trace through a whole network of matings and learn the sex of many other banded birds. The important thing was to find an old swift that had mated with many different birds. Such an individual was No. 615. Although it upset me to kill a bird I had known for many summers, the success of my research depended upon learning its sex.

Once I knew No. 615 was a female, I marked all the other swifts so that I could recognize each one without having to handle it. I pasted a duck, chicken, or gull feather to a specific part of each bird. For example, if one swift had a white chicken feather on its back, no other swift would be marked that way. It was a fine idea, I thought, until the feathers became unstuck.

Next I tried putting dabs of paint on various parts of the swift. No more problems. In fact, I could sometimes recognize an individual hundreds of feet away outdoors (using binoculars, of course). Now I could identify every swift without having to catch it and read the band number.

The Nest-Building Puzzle

Swift nests are among the oddest in the entire bird world (*see pages 8 and 9*). The chimney swift uses its saliva as glue to hold together a nest of sticks. One of the barns I visited was ideal for studying nest construction. It certainly was a peculiar setting, though. The owner, for some reason, had tacked an immense couch cover to the roof timbers. It hung down, nearly reaching the floor. Chimney swifts found a single missing pane in a window of the barn, so they explored the inside for a nesting place. They liked what they found, making their nest on the couch cover.

Everything went fine there for the swifts and me, summer after summer. I used to take my lunch to the blind so I could spend long uninterrupted periods of observation. There I saw the swifts mate at their nest place, learning that chimney swifts do not mate in the air as many people believe. By observing these "couch cover" swifts, I also discovered that both male and female birds share the jobs of incubating eggs and caring for the young.

One spring I took my vacation early in order to be in the study area at nest-building time. When I arrived at the barn, full of expectations, the couch cover was gone! What would the swifts do? After dark I sneaked into the barn with a flashlight to see if any swifts were sleeping there.

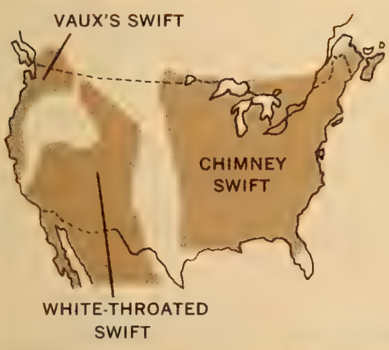
This mother swift is warming her young after feeding them. Swifts are naked and blind at birth. The author put white paint on the wing of the mother to identify her.

Sure enough, I spotted a pair clinging to the boards at one end of the building. I was very careful not to alarm them. Next morning they were gone.

The owner of the barn had not returned from his winter home, but I had permission to do anything I wished to help my chimney swift research. Losing no time, I found a huge rug and hung it where the couch cover used to be. Since the couch cover always had at least one old nest on it, I took a nest from my collection and wired it to the rug in about the same spot where last year's nest had been.

Each night I stole a brief glimpse at the sleeping swifts to be sure they were staying. They clung to the rug, huddled together. They seemed to prefer one spot on the rug for sleeping and chose that spot for their nest.

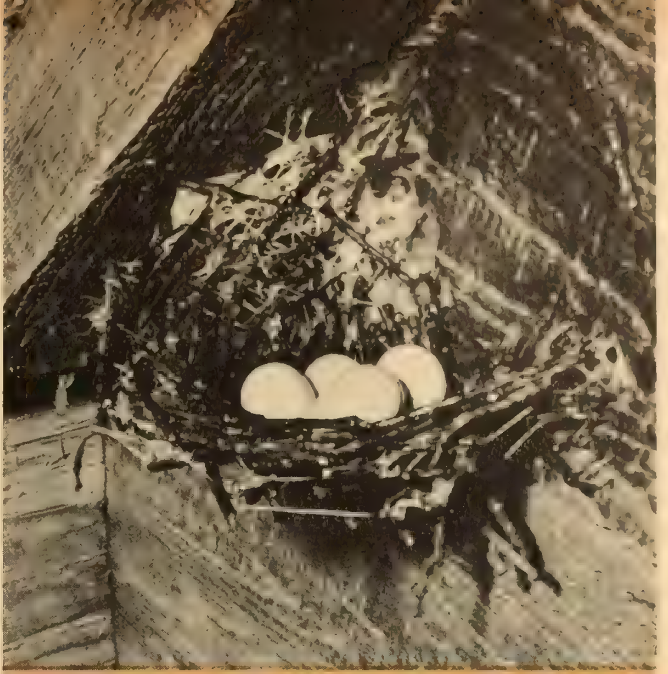
The swifts did all their building in the afternoon. (Why swifts build their nests only then is still not known.) Each bird did its share. To gather twigs, the birds flew at a thin dead branch and snapped off a short piece, usually with both feet but occasionally with their bills. Chimney swifts, incidentally, never pick things off the ground. A swift always arrived at the nest with a single twig clutched in its bill. The builder would attach his twig, already moistened with sticky saliva, to the others in the nest. Then the bird would touch its bill to various parts of the nest to add more "glue" where needed. A shapeless jackstraw arrangement at first, the nest gradually took the shape of a half-saucer (*see photo above*).



The chimney swift is a common bird in the eastern United States. This map shows its range and the range of two western swifts.

The swifts had been at work on the nest nearly two weeks—a long time for a small bird—and were still going strong when I discovered the nest contained their first egg. By the time they had five eggs the nest was little more than half finished. (This surprised and puzzled me. Most birds complete their nest before they lay any eggs.)

The swifts began incubating the eggs and went right ahead with nest building. The adults took turns on the eggs, often sitting for more than two hours. When a swift came in to relieve its mate, it usually brought a new twig and added it to the nest. It daubed on more "glue" here and there while sitting on the eggs.



The nests of chimney swifts are made of twigs held together with sticky saliva. Swifts keep building the nest while they are laying and warming their four or five eggs.

After 19 days, the eggs hatched. It was then that nest building ceased. So that was it! The chimney swift saves time by building half the nest during the long egg-laying and hatching period. Were it not for this remarkable behavior, swifts might not have time to raise their young during the short summers of northern North America.

From the Mouths of Babes...

When the nestlings hatched there were new observations to make, new secrets to uncover. By studying many families over a period of years, I pieced together another chapter in the chimney swift's life story. It was easy to tell when the eggs had hatched. The parents simply tossed the shells out of the nest to the floor below. (Many other birds carry them away.)

The parents took regular turns feeding their young. At first the little ones seemed barely strong enough to raise their heads and gulp the insect food spit up (*regurgitated*) by the parent. After feeding, the parent would settle over the babies to warm them until the mate came with food.

By the end of the first week the young weighed five to six times their hatching weight. Though their eyes were not open until they were two weeks old, almost any sound from the parents would start them begging for food. At this age and afterward a parent fed only one young bird on a visit.

(Continued on the next page)

The adult would stuff a huge tangled pellet of living and dead insects into the nestling's throat. What did those pellets contain? How could I find out? The answer was simple enough: Get some and see!

After a parent fed, I waited until it flew away for more food. Then I climbed hastily up to the nest. Grasping the young swift's neck to keep it from swallowing, I took the bird back to the blind. There I gently forced the food pellet—about the size of a jelly bean—from the bird's throat into a small bottle of alcohol. The alcohol kept the food pellets from decaying. Later on I had time to take the food pellets from the alcohol and discover what the parent swifts had caught for their young. The pellets were usually a mixture of a hundred or more tiny flies, tree hoppers, wasps, mayflies, and stoneflies.

Chimney swifts do not feed their babies as often as many other birds. The loss of one pellet would have been serious for a nestling. To replace the food pellet, I gave the bird a substitute meal—insects which I had caught myself—before putting it back in the nest. Some boys and girls from the neighborhood helped me weigh, feed, and photograph all the baby swifts.

The Long Flight South

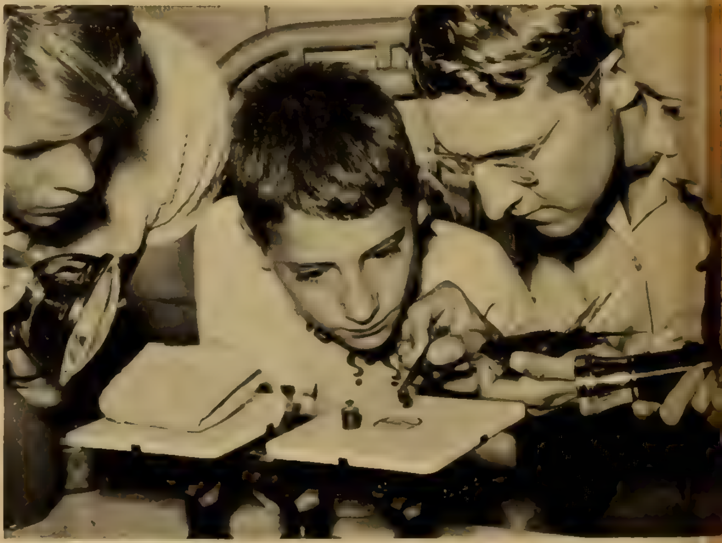
The young swifts grew rapidly. At two weeks of age their eyes opened and glossy black feathers popped out of their quills. In another seven days they could see well and had begun short flights near the nest. Then the day came when the first little swift ventured outdoors. Most of the others also took their first flights that day. They would return to the nesting wall for rest, and at night the entire family would sleep together near the now empty nest. This sort of behavior went on for several days.

As time passed, the family group slowly broke up. The swifts visited other barns, silos, and chimneys in the area before starting for their winter homes.

It is a long, hazardous journey, all the way to the wild rain forests at the head waters of the Amazon River in far off Peru and nearby countries. Next year only a little more than half of the adults and one-tenth of their young will survive the long trip and return to their nesting places. Then you and I can try once more to learn more secrets of the swift ■

What about Other Birds?

This coming spring and summer, investigate the nests of birds in your neighborhood. Watch for birds carrying string, grass, and other nest-building materials. Try to find and observe the nest. In how many days is it finished? Do both male and female birds take turns sitting on the eggs? What food do the adults bring to the young? Watch the birds from a hiding place so you don't disturb them. The less the birds see of you, the more you will learn about them.



These photos show the author taking the temperature of a swift *(left)*, and preparing to weigh one *(right)*. Dr. Fischer often worked at night, when he could easily catch the sleeping birds. Boys and girls from the neighborhood helped him. Dr. Fischer, who has studied swifts for 14 years, is an associate professor at Cornell University.

Using This Issue...

(Continued from page 2T)

the energy bonds. When the melting point of a solid is reached, a certain amount of heat must be added to overcome the bonding energy. The amount of heat needed to change a gram of substance from a solid to a liquid is called the *latent heat of fusion.* Only when the atoms have gained enough energy to break their fixed pattern and slip and slide over each other (Diagram 2) will additional heat begin to raise the temperature.

When the water begins to boil, its temperature stays at 100°C even though more heat is being added. Can your pupils explain why? Have them look at Diagrams 2 and 3 on page 5, showing the atoms of a substance in liquid and gaseous form. When a liquid has been heated to its boiling point, additional heat is again needed, this time to break the atomic or molecular bonds keeping the substance in a liquid state. The amount of heat needed to change a gram of a substance from liquid to vapor is called the *latent heat of vaporization.* (To change a gram of water into steam, for instance, takes nearly seven times the amount of heat needed to change a gram of ice to water.) Only when the liquid has been vaporized will additional heat increase the speed of the atoms or molecules and raise the temperature.

If a container were sealed shut so that the steam could not escape, would the temperature of the steam rise as heat was added? Perhaps some of your pupils have seen their mothers cook food very quickly in a pressure cooker. The food is placed in the pressure cooker with a small amount of water, and the cover is sealed on. As the pot is heated, hot air escapes through a valve in the cover. The water boils in a few minutes, making steam that pushes the valve in the cover closed. Continued heating raises the temperature of the steam rapidly, cooking the food in a fraction of the time it would take to cook in a pan of boiling water that was not sealed.

8 Cradles for Birds

Each kind of plant and animal is adapted to survive in its environment. The chart illustrates this concept by showing a variety of nests (and non-nests) that exist today—the product of millions of years of evolution.

There are no fossil nests to help scientists trace the evolution of nesting, but some understanding of nest evolution has been gained by comparing the nests of different species. For example, different degrees of evolutionary development can be seen in birds that nest in cavities, ranging from those that simply use natural holes in trees to those that tunnel six feet or more into stream banks. Hole-nesting goes a long way toward meeting the essential nest functions of warmth and safety, so hole-nesting birds usually have rather simple nests inside the holes.

As the chart shows, the Mallee fowl incubate their eggs in much the same way as some reptiles. However, scientists believe that these birds once had "normal" nests and have since evolved an incubation method that is like that of reptiles. Actually, the Mallee fowl have efficient control over the temperature of their eggs, far beyond that of any reptiles.

Topics for Class Discussion

- *In what ways are the eggs of ground-nesting birds protected?* Some eggs blend with their surroundings, and so do some of the birds incubating the eggs. Nests on or near the ground are usually well-concealed. Have your pupils look in bird books for information on the adaptations of ground-nesting birds in your area.
- *Would it help young ground-nesting birds to survive if they could leave the nest right after hatching?* Yes. Most of the *precocial* birds (hatched with eyes open, covered with down, capable of leaving nest) are ground-nesters. Quail, pheasants, ducks, and geese are precocial birds. Most birds have *altricial* young (blind, naked, and helpless) which must stay in the nest for some time.

Activity

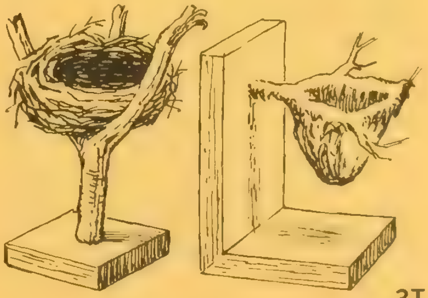
A collection of *abandoned* bird nests can be a worthwhile project. Whenever possible, the nest should be collected along with its support—a piece of sod, a forking branch, some weed stems. Then the nests can be displayed on wooden stands *(see diagrams).* The nests will have much more value if each is labeled with information about its maker, location, height above the ground, and so on. The books listed on page 7 will help you identify the nest makers.

13 Swifts

This article reveals the approach scientists use when dealing with the unknown. Dr. Fischer first established what was known and unknown. Then he set out to gather information.

Topics for Class Discussion

- *What specific things did Dr. Fischer want to find out about the habits of chimney swifts?* He wanted to watch them build a nest, to examine the eggs, to record the growth of the young, and to discover what insects they catch as they fly.
- *Do you think that Dr. Fischer's methods of studying chimney swifts are typical of the way most scientists think and work?* Yes. Fischer first listed the questions he wanted to answer. He then set up techniques of observation, data collecting, and recording of information to enable him to answer his questions. When something didn't work (as with the first marking system he tried), another approach was tried.
- *Where do you think chimney swifts lived before there were any chimneys?* They built nests in such places as hollow trees. They still nest in such sites in wilderness areas.
- *Why do you think it was so important for the swifts to begin to incubate their eggs before their nests were complete?* New-born swifts require a rather lengthy stay in the nest. They begin to fly in late July and early August (in New York State where Dr. Fischer studied). Since swifts depend entirely on flying insects for food, they begin migrating south by early September at the latest.
- *Have you ever heard of the famous Oriental dish called bird's nest soup?* Swifts secrete a sticky saliva that they use when building their nests. Some species of Asiatic swifts have particularly large saliva glands. They build a small cup nest that is made entirely from hardened saliva. These nests are gathered, cleaned, and used to make bird's nest soup.



Do You Know as Much...

(continued from page 1T)

learned them in school, but because they have never known anything else. They take for granted what to the adults is still essentially strange, unexpected, and to a degree unbelievable.

For the child, the possibility of world-wide destruction if the bomb is used is something he has grown up with. The adult still tries to argue himself out of it, speaking of being willing to risk nuclear war to preserve freedom, and is unable to realize there would be no people left to enjoy that freedom. The children of today live in a new world, accepting its strangeness as usual, and so approach it quite differently—not because they are children, but because they are children in this particular period of history.

In the relationship between teachers and students at the university level this is vitally important; it is only those who listen to their students, eagerly and humbly, who have a chance of keeping up in the modern world. In the United States it is the grandparents who live in close touch with their grandchildren who still have some idea of what is happening in the world around them.

As Much Learning as Teaching

The teachers of children are in a very special position. They now have to do almost as much learning as they do teaching, if they are to make what they teach intelligible to these new children, natives of a new age.

It was regarded as a great advance in education when we began to teach future teachers something about the nature of the child mind—just how children think; how much one can expect them to learn at different ages; how much one child differs from another in memory and comprehension, and in the ability to use abstractions, to use their hands, to use all their senses. In this new situation all that has been learned about children is still true; they are still children with children's capacity to attend to a long exposition or to handle a multiplicity of data. And all that has been learned about their recently unguessed capacities to handle mathematics is also true.

But I am speaking of something different, of the content of their minds rather than of how their minds work. Adults remain both more experienced and more intellectually mature than children, and children need their teachers as much, if not more, than ever. It is in what the children know that is relatively new to the teachers that the difference comes. How can the teacher handle the wonder and surprise in his own voice and still meet the matter-of-factness in his pupils' voices without somehow making the children feel that he is old hat—and risking the children's rejection of all that he still must teach them?

One method is for the teacher to bring into the classroom things that are so new that even the children have not grown accustomed to them. Thus the children can experience some of the surprise and wonder which the teacher himself experiences. Then, using this element of shared wonder, the teacher can lead the children backward into a world where all that is now commonplace was new, and nothing that is now taken for granted was believed to be possible. In this way teacher and pupils are again joined in a common point of view, but the teacher is again in the lead, bringing his greater astonishment to supplement the lesser astonishment of the children.

Knowing What Children Expect

To do this the teacher must know the daily fare on which the children are fed—via TV, in comics, even in jokes and rhymes—which has sharpened their expectation of what will happen next. If the teacher doesn't have a continuing familiarity with experiences such as the heart operation on TV, or the program discussing the possibility of freezing a dying man until a cure is found for his disease, he will not know what his pupils are thinking about. However careful he may be, he will not be able to teach them what they need to know, because he does not know what they already expect and believe.

Perhaps because it is so hard to think imaginatively and immediately in the children's terms, science teaching has come to be very rigid, with the teacher clinging to a certainty that his pupils' minds work the way his does. If the content of what they know is strange, at least he can welcome the child whose mind is familiar. This has also some very serious results for the future of science, because children whose minds work in other ways than the teacher's are often discouraged very early from going on with science.

If the teacher can separate the problems that come from his pupils' knowledge of things that are strange to him from the problem of how their minds work, he can be more hospitable to different kinds of minds, to girls in the physical sciences, to boys in nature study, to children who think in images or in physical models rather than in words and figures.

The more the modern science teacher can keep up with the world in which his pupils live—a world in which he is an immigrant from another period—the more he can teach them what he knows that they do not ■

LEE BOLTIN

"The modern scientific revolution has affected every aspect of our lives and the children know these new things . . ."

nature and science

TEACHER'S EDITION

VOL. 3 NO. 7 / DECEMBER 20, 1965 / SECTION 1 OF TWO SECTIONS

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ABOUT THIS ISSUE...

Exploring the Oceans

■ To say that man is a land animal may seem obvious, but in using this special-topic issue on the oceans, it is worth emphasizing to your pupils. We are at home on that one-fourth of the earth's surface that happens to be above the ocean's surface. We breathe a remarkable substance—the earth's atmosphere—and we can see through the atmosphere to the stars. Indeed, on the whole, we have better maps of the moon than of the ocean bottom.

Although the first organized oceanographic expedition took place almost a century ago, with the voyage of the British vessel *Challenger*, it is only in the last two decades that man has done much more than test the water with his big toe.

Living and Working under the Sea

We have now, however, taken the plunge. This past fall we have seen two major experiments in which men lived under the sea for extended periods. The lead article in this issue deals with one of these experiments, Sealab II, which was sponsored by the U.S. Navy. The other was the latest in a series under the direction of Jacques-Yves Cousteau, the well-known French diver.

As an environment for man, the ocean depths are—not surprisingly—quite unfriendly. Much of the effort in these current experiments is directed toward investigating and overcoming the technological problems of creating an artificial system in which men can live under the sea. (The efforts to understand and prevent shark attacks, discussed in "The Deadly World of Sharks," also gains importance as humans explore the ocean more and more.)

This is not to say that the only way to learn about the ocean is to live in it. Most oceanographic research is carried on from vessels specially fitted out to make a variety of complex measurements. Not only is the ocean bottom charted *(see "Landscape of the Deep")* but samples of the sediment on the ocean floor are brought up to the surface. From thousands of such samples, geologists and paleontologists are piecing together the past history of the oceans—and of the earth. The current attempt to drill down through the earth's crust to the mantle, known as Project Mohole, is being carried out from a platform on the surface of the sea.

Studying Undersea "Weather"

The nature and abundance of life in the sea *(see* Wall Chart *and page 3T)* is directly affected by an enormously complex web of factors which might be thought of as underwater weather. These factors are the subject of continuing research and investigation. For example, the temperature and salinity of the water have been found to vary widely. "Surface" currents such as the Gulf Stream and deep underwater currents are being charted more accurately. Surface waves seem simple enough *(see "What's in a Wave")*, yet scientists are still trying to find out exactly how they are generated and how waves from different sources affect each other; they have only recently discovered that there are huge waves down in the ocean depths.

In short, the oceans represent a whole new world to be explored. Oceanography is a relatively new "science" that combines marine biology, physics, geophysics, geology, chemistry, and a host of other specialties.

In addition to sheer curiosity, there are a number of practical reasons why man wishes to learn more about the oceans, even to the extent of enduring

(Continued on the next page)

IN THIS ISSUE

(For classroom use of articles preceded by ●, see page 2T, 3T, 4T.)

● **Man Under the Sea**
In Sealab II and other undersea programs, men are beginning to solve the problems of living in the environment beneath the oceans.

● **Who Eats Whom**
The interdependence of plants and animals in the food chains of the seas is shown in this Wall Chart.

● **What's in a Wave?**
By making and measuring waves, your pupils can find out some of the basic elements of them.

Landscape of the Deep
The ocean floor has mountains, deep valleys, and plains. This article describes the ocean landscape and tells how man is charting it.

● **The Deadly World of Sharks**
How a panel of biologists has gone about studying the lives of sharks in an attempt to prevent shark attacks on humans.

IN THE NEXT ISSUE

Life on other planets? . . . Test the effects of colored light on green plants . . . How the size of an eye's pupil is affected by a person's interest . . . A Science Workshop on mixtures and solutions . . . Albino animals: why they occur and why they seldom survive.

Exploring the Oceans
(continued from page 1T)

the discomfort and the expense of trying to live there.

Life from the sea forms a major part of the diet for many of the people of the world and as the world population increases, so will the importance of this source of food. But our fishing methods are very old-fashioned. In years to come fishermen will use echo-sounders to locate big schools of fish, lights to attract them, electric currents to stun them, and huge suction pumps to scoop them up. Besides catching more fish, we will probably have to grow more. Much as in the Japanese pearl industry, stretches of shallow water near the shore may be fenced off, and young fish will be "transplanted" there to be tended by sea-farmers in flippers and diving masks. In one of Cousteau's experimental programs, men herded fish with a certain amount of ease.

Minerals, such as bromine and magnesium, have already been extracted from the sea, and others will certainly be in the future. Fuel in huge amounts is known to lie under the ocean floor. Both of the recent man-in-the-sea experiments were directly concerned with the problems of establishing underwater oil-fields in the shallow waters of the continental shelves.

"Preventive" Conservation

There is another practical—and important—reason for learning more about the sea. The increased exploitation of this "new" world by man could easily bring with it a major dislocation in the complex web of ecological factors that operate in the oceans—factors about which we are still largely ignorant. Who knows, for example, how extensive are the ramifications of throwing human pollutants, including radioactive waste materials, into the sea?

The resources in the oceans are no more endless than those on land, as shown by the threatened extinction of whales through "overkilling" by commercial hunters who do not abide by international agreements. Awareness of the need for managing the natural resources of the land has come late; in the oceans, we still have an opportunity to practice "preventive" conservation.—JAMES K. PAGE, JR., *editor for this special-topic issue.*

USING THIS ISSUE OF NATURE AND SCIENCE IN YOUR CLASSROOM

2 Man Under the Sea

Like all living things, humans are adapted to the environment in which our species has developed. Our environment is the surface of the earth, which is at the bottom of an "ocean" of air. In order to survive in a foreign environment—the watery oceans or airless space—we must create an artificial environment that has certain vital elements of our natural environment. This account of the Sealab II experiment pinpoints some of the problems man faces in living in an artificial environment under the ocean. It also gives some of the reasons why we are now devoting so much effort and money to exploration of the oceans *(see also the article beginning on page 1T).*

Topics for Class Discussion

- *What are the important elements of man's natural environment that he needs to survive undersea or in space?* The first is oxygen, which we need to change food into energy. The earth's atmosphere is about 21 per cent oxygen, the remainder being nitrogen (78 per cent) and other gases. The oceans contain some free oxygen (about 5 parts per thousand), but this concentration is not enough to supply a man's needs even if his lungs were equipped to recover it—which they are not. So oxygen must be supplied to men undersea, either in the "atmosphere" of their living quarters or through a tank-fed mask. Space ships and suits must also supply oxygen to *astro*nauts, for the simple reason that there is none in space.

The need to supply *aqua*nauts with a mixture of gases under pressure so that the weight of the water pressing on them does not collapse their lungs is explained in the article. In space, there is no atmosphere, so an artificial one must be produced—one that can be breathed, and one that is dense enough to provide pressure sufficiently high to maintain the body. For example, at an altitude of 50,000 feet, without protective equipment, it would be impossible to breathe. Waste gases entering the lungs build up a pressure of 1.69 p.s.i. Because the atmospheric pressure at this altitude is the same value, there is no way for oxygen to enter the lungs. At an altitude of 63,000 feet atmospheric pressure is so low that at normal body temperature the body fluids would seep out through the skin and evaporate, or "boil" away.

While the problem for *astro*nauts is to maintain an artificial environment in which the air pressure is high enough to maintain bodily function, the problem of *aqua*nauts is to guard against pressures so high that they interfere with the body's operation.

Temperature, too, is a problem. While the *aqua*nauts could work for a while in water at about 50°F without wearing heated suits, they can work more effectively for longer periods when protected from the cold. In the "thin" atmosphere, the cold is much more intense than it is in the coldest parts of the ocean. So an *astro*naut's capsule or space suit must be heated to keep him from freezing to death.

- *Can you think of some other differences between working under the sea and in space?* Visibility is poor under the sea, even with powerful lights. (You might point out that since the aquanauts could see only about 15 feet through the murky water, Sealab II would not actually have been visible to the aquanauts shown in our cover illustration.)

An object under water is not "weight-

(Continued on page 3T)

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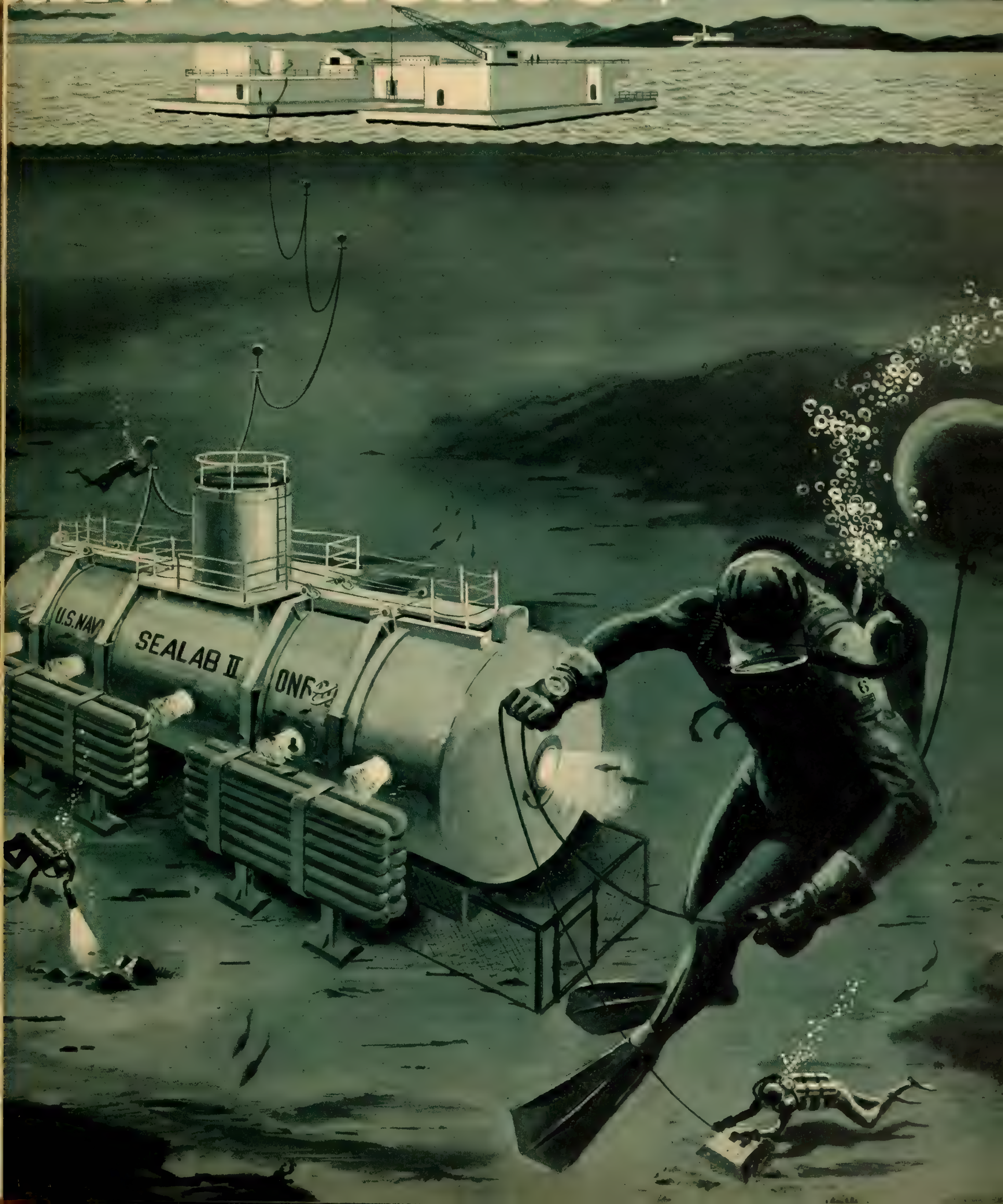
nature
and science

VOL. 3 NO. 7 / DECEMBER 20, 1965

SPECIAL-TOPIC ISSUE

INTO THE OCEAN WORLD


U.S.NAVY
SEALAB II
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nature
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science

VOL. 3 NO. 7 / DECEMBER 20, 1965

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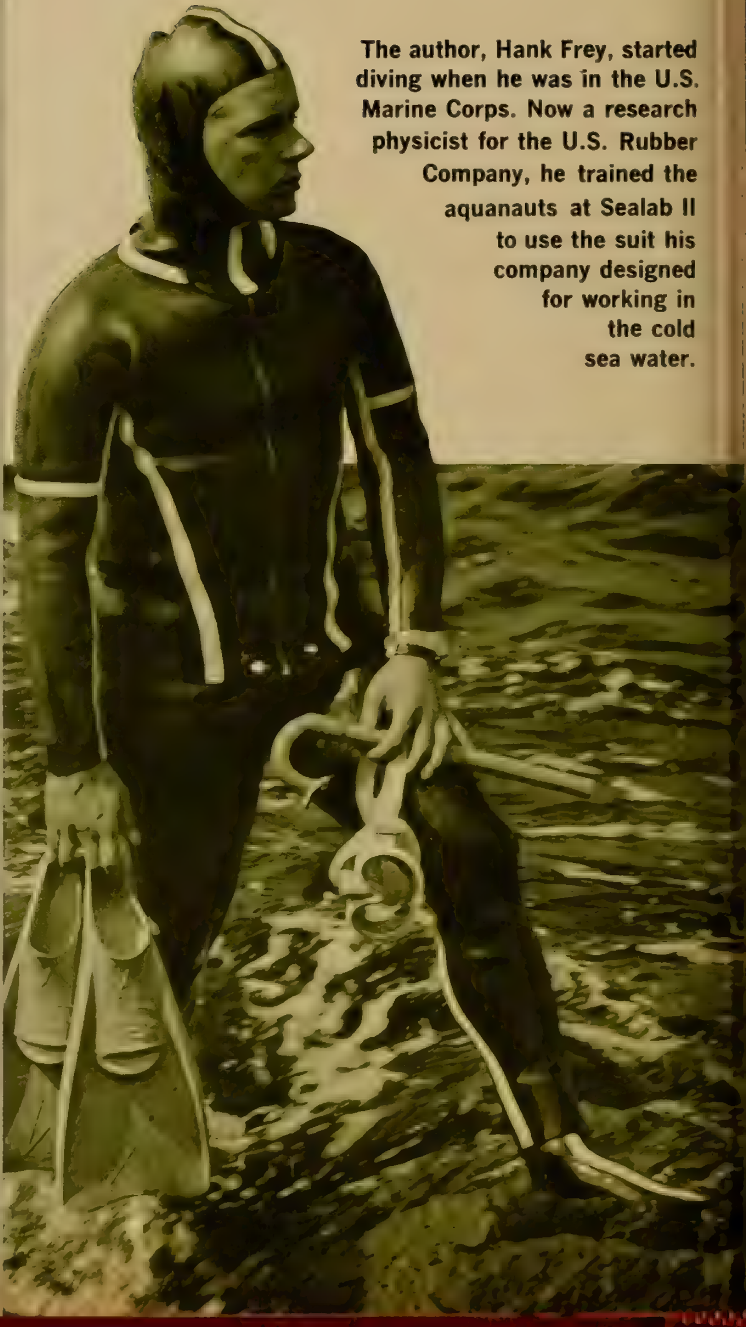
man under the sea

by Hank Frey

A scientist's report on Sealab II and the aquanauts who lived and worked in the ocean depths.



The author, Hank Frey, started diving when he was in the U.S. Marine Corps. Now a research physicist for the U.S. Rubber Company, he trained the aquanauts at Sealab II to use the suit his company designed for working in the cold sea water.

■ Have you ever heard of a porpoise delivering mail? Or men swimming out their front door to put the garbage out? Or big brawny men who sound like Donald Duck? Or houses on the bottom of the sea? As strange as they seem, all of these things took place just a few months ago off the coast of California.

The United States Navy conducted an experiment in which men lived under water in a special submarine house called Sealab II. Three teams of aquanauts took turns living and working together for 15 days at a time 205 feet below the surface in one of the most exciting underwater programs ever accomplished. I had the pleasure of working on the Sealab II program as one of the many research scientists who worked at the surface. My job was to develop heated rubber suits that would keep the divers warm in the cold water.

The aquanaut teams were made up of both Navy divers and civilian scientists, and each man was outstanding in his particular field. As you know, the team leader during the first 30 days was Commander M. Scott Carpenter, who also orbited the earth in Aurora 7 in the Mercury spaceflight program. Commander Carpenter is an exceptional man: a keen observer, a natural leader of men, a good engineer, and a serious and hard worker with a good sense of humor and lots of courage. Chief Bob Sheats was the team leader for the third team period. Chief Sheats is fondly known as the Master of Master Divers. At the age of 50, he can outswim and outdive just about any man in the Navy and has the well-earned respect of all divers.

Now, 205 feet below the surface may not seem like a very great distance to you. It is just about the length of a short city block. But that 205 feet above the aquanauts was probably the longest 205 feet imaginable. At that depth the water presses on your body about seven times as hard as the atmosphere is pressing on it right now.

You are sitting under a column of air that extends right up to the edge of the atmosphere. At sea level this column of air presses down on each square inch of your body with a weight of 14.7 pounds. Fortunately for you, the air inside the cavities of your body, such as your lungs, is pressing outward with the same force.

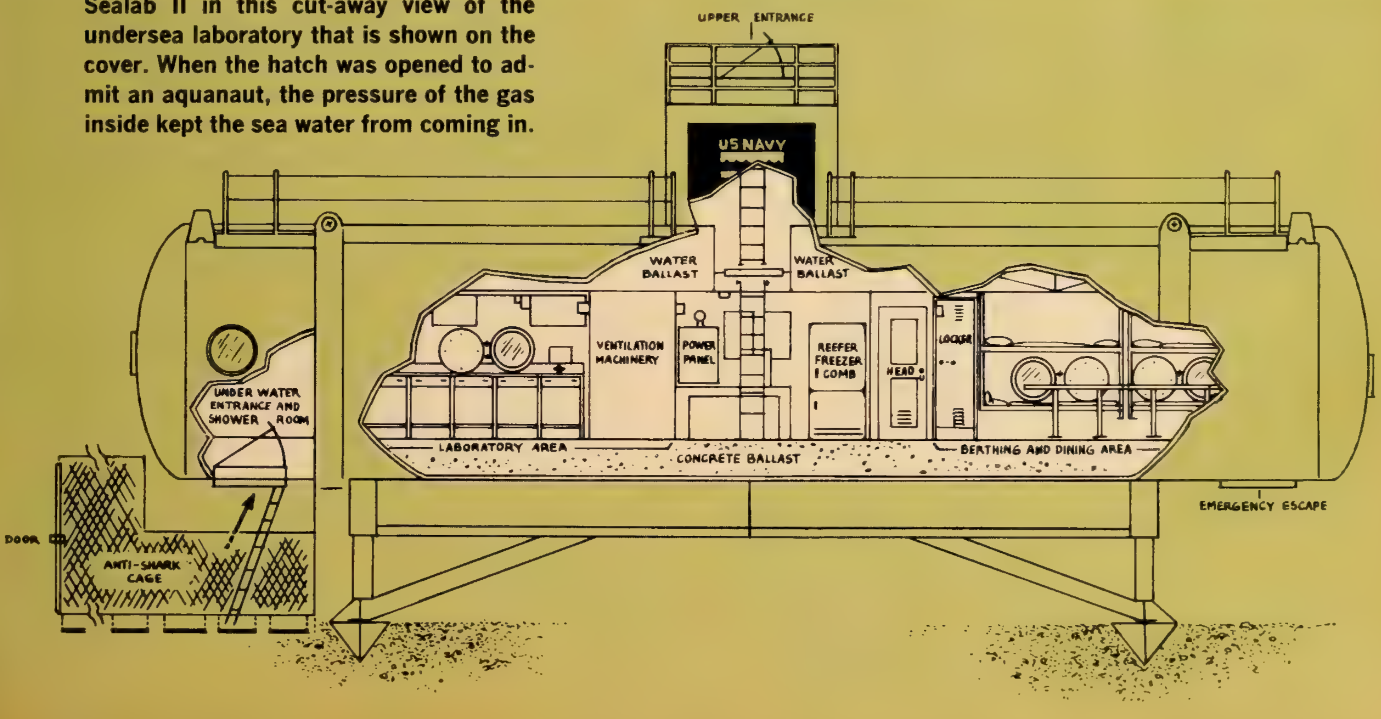
If the pressure of the air in your lungs were less than the pressure on the outside of you, your lungs would collapse. Since water is 800 times heavier than air, a column of water only 30 feet tall would press down on you with as much force as the column of air that you "support." At 205 feet below the surface of the water, the pressure would easily collapse a diver's lungs. So, divers breathe air or other gases that are compressed so that they push against the inside of the diver's lungs just as hard as the surrounding water is pushing against the outside of the diver's body. Actually, the biggest problems for divers come from the indirect effects of these compressed gases.

The Bends

The compressed gases a diver breathes dissolve into his blood and tissues and stay in solution so long as the diver does not rise to the surface rapidly. But if he does rise rapidly, the gases come out of solution and form bubbles

(Continued on the next page)

You can see the inside arrangement of Sealab II in this cut-away view of the undersea laboratory that is shown on the cover. When the hatch was opened to admit an aquanaut, the pressure of the gas inside kept the sea water from coming in.



One of the many schools of fish that visited Sealab II can be seen through the kitchen porthole. Sealions also visited the aquanauts, and one even poked his head in through the hatch.

around his bone joints, causing great pain. This condition is called the "bends."

Every time you open a bottle of soda pop, you see in front of you a perfect illustration of the bends. Gas has been forced into the soda pop under pressure and when you open the cap, the pressure inside the bottle forces the gases out in the form of many bubbles. But if a diver comes up slowly, the gases slowly come back out of the blood and out of the tissues and pass out of his lungs with his exhaust gas.

A diver can breathe compressed air if he is not going much deeper than 130 feet. Below this depth the nitrogen in the compressed air causes *narcosis,* a feeling very much like getting drunk. And, just as a drunk driver isn't a safe driver, a drunk diver isn't a safe diver. But there are gases which do not cause this drunken, or narcotic, effect. One is helium, a gas much lighter than nitrogen. The Sealab II divers breathed a mixture of helium, nitrogen, and oxygen, but the amount of nitrogen was kept below the level at which it could cause narcosis.

Helium Speech

A very amusing thing happens when a man breathes gas with a high percentage of helium in it. His voice sounds very strange, much like Donald Duck. Even a deep bass voice comes out as squeaky shrills.

In the months of training before they entered Sealab II, the aquanauts had gotten used to the normal sound of each other's voices. When they first went down into Sealab and heard each other squeaking, it was hilarious. On the surface we could hear their uncontrollable laughter through the intercommunication system. One big brawny Navy diver opened his mouth to say his first words down in the Sealab and thought he sounded like a little girl. He was so embarrassed that he closed his mouth and didn't talk for three days. But after a while, they all became used to the helium speech and went about their business as usual.

While down in Sealab II, the aquanauts tried to compensate for the helium speech by trying to speak in a deeper voice. After they returned to the surface, we noticed that their voices seemed to be deeper than they were before they dived down to Sealab II. I asked Commander Carpenter and the other aquanauts each to talk into a tape-recorder I had with me. It seemed that their voices had all dropped by almost a full octave.

Getting To Work

Of course, it was not all laughs in the Sealab II. There was a great deal of work to be done. One task was to set up an underwater weather station on the ocean bottom. Another task was to try out new kinds of equipment for diving and salvage operations. To do this meant spending four or five hours at a time in the cold and murky water.

In fact, the cold water (50°F) and the poor visibility were the two most serious problems the aquanauts faced in this new environment. At 205 feet a Sealab II diver could only see about 15 feet, and even using lights didn't help much. It was because of the bad visibility that two of the divers met the scorpion fish. Scorpion fish have very sharp spines on their backs which release a liquid that causes severe pain. The fish aren't aggressive but it is so dark that it is difficult to see them. Two accidents occurred when the divers were groping around in the murky water and by chance put their hands on the spines of the poisonous fish.

There really wasn't very much anyone could do about the poor visibility, but the heated diving suit was help against the cold. When he came up to the surface, Commander Carpenter said that he thought divers will be able to stay out in cold water for as much as eight hours at a time with future models of the suit.

A number of scientific investigations were carried out during the Sealab II program. Many of these were to find

Inside Sealab II, Commander M. Scott Carpenter (left) checks the controls of an aquanaut's electrically heated "wetsuit" in preparation for an underwater test of the suit.

out how men would hold up under such artificial living conditions. Navy medical scientists wondered if the aquanauts would have any trouble getting along with each other—or with themselves—while they were cut off from the rest of the world in an underwater shelter for such a long time. The aquanauts in Sealab II were studied by psychologists up on the surface who could watch and hear them with the aid of television cameras and hidden microphones. No serious effects on the aquanauts' behavior were noted, but some of them suffered from headaches and other minor discomforts.

Two civilian scientists working in Sealab II carried out an experiment in which they attempted to grow marigolds and barley in the "head" (men's room). They wanted to see if these plants would grow in the atmosphere of high-pressure mixed gases they were breathing in place of air. The marigolds didn't do very well, but the barley grew successfully.

Tuffy, the Messenger

The Sealab II experiment was not confined to the activities of men alone. Tuffy, a male porpoise, proved that trained animals can be very useful to men who live in the sea. Within a 20-minute period, he made seven beautiful dives down to Sealab II in rapid fire sequence. He delivered the mail to the aquanauts, carried packages of tools down to them, and brought down his own lunch so that the aquanauts could feed him.

Tuffy had been trained to find aquanauts in trouble and to help them to return to Sealab II. If a diver got lost or in trouble, one of the aquanauts would signal Tuffy and the porpoise would come speeding down from the surface to the bottom. The aquanaut would then tie a short line onto a harness that Tuffy wore, and the animal would tow him to the diver in trouble. Then all three would return to Sealab II. The porpoise experiment was successful and Tuffy performed exactly as he was expected to.

Going Up!

At the end of each team's period on the bottom, the aquanauts swam out of the Sealab II and sealed themselves into a large cylindrical chamber called the Personal Transfer Capsule,, or PTC. They were then raised up to the mother ship on the surface and transferred into the decompression chamber. They stayed in there for a little more than 30 hours while the pressure was gradually decreased, to allow the bubbles of helium to slowly leave their bodies.

(Continued on the next page)

In this stretcher, Tuffy the porpoise was flown by helicopter to the Sealab II site, where he worked as messenger.

Man Under the Sea (continued)

You may wonder why the Navy went to all this trouble. There are several good reasons. A man who lives in a sea-house will be able to do useful work in the water for periods up to about 8 hours per day. He should be able to do this for about 30 days. Thirty days times 8 hours per day is a total of 240 hours of work. It takes 30 hours to decompress the man, so that for each one of these 30 hours he spends in the decompression chamber he has spent 8 hours working in the water. In some cases in the past, a man would have to spend as much as 8 hours decompressing for only one hour in the water. So, this new way of diving lets men spend much more time working underwater, and in the long run it will be less expensive than the old way.

More time and less expense for doing what? The surface of our planet is about three-quarters water, and only one-quarter land. We mine and farm the land, but we have done very little to take natural resources from the oceans. It is possible that men will someday live in houses on the bottom of the sea and mine the sea's minerals, drill for oil at great depths, and raise food on underwater farms and ranches. Before this can happen, though, we will have to have more scientific knowledge of how men behave in an underwater environment, and we will need more advanced engineering methods for building the homes and tools that men will need if they are to live and work underwater.

Many other expeditions are planned in the United States Navy Sealab program and two similar programs are being conducted by an American company and by the French Navy. What is learned from these three man-in-the-sea programs may show us how to live and work under the oceans of our earth and recover more of their rich treasures of food, fuels, and other useful chemicals ■

France has a man-in-the-sea project called Con Shelf (for Continental Shelf), directed by Captain Jacques-Yves Cousteau, the famous French underwater explorer who invented the Aqua-lung. Last October, in Con Shelf III, six oceanauts lived 330 feet below the surface of the Mediterranean Sea off the French coast. Captain Cousteau is shown on an underwater holiday with his wife and two young sons.

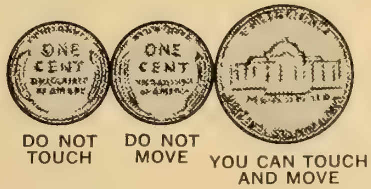
If you would like to read more about the oceans, look in your library or bookstore for these books: **The Sea Around Us,** by Rachel Carson, edited by Anne T. White, Golden Press, New York, 1958, $4.95; **Tide Pools and Beaches,** by Elizabeth Clemons, Alfred A. Knopf, New York, 1964, $2.95; **World Beneath the Oceans,** by T. F. Gaskell, The Natural History Press, Doubleday & Co., Inc., New York, 1964, $4.95; **Wonderful World of the Sea,** by James Fisher, Doubleday & Co., Inc., New York, 1957, $2.95.

In 1960, the U.S. Navy's bathyscaphe *Trieste,* a special deep-diving submarine, carried two men in its ball-shaped cabin to the bottom of the Challenger Deep in the Pacific Ocean. It rested on the bottom, 35,800 feet down, for 20 minutes in the deepest dive man has ever made.

brainboosters

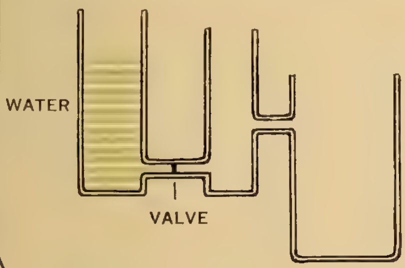
prepared by **DAVID WEBSTER**

Can You do it?



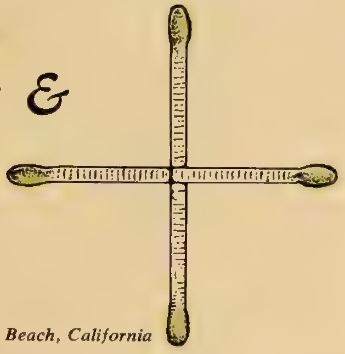
Can you get the nickel between the two pennies? You must not touch the first penny and you cannot move the second penny.

What would happen if...?



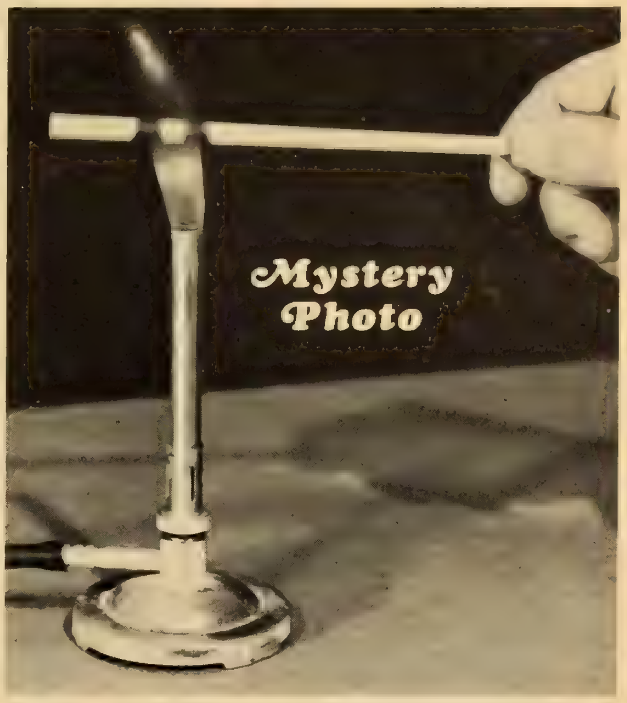
Where would
the water
go
when the
valve
is opened?

FUN WITH
Numbers & Shapes



Make a square
by moving
only one match.

submitted by Joe Velson, Long Beach, California



The stick was held for a few seconds in the gas flame. What is unusual about the way the stick is burned? Do you know why?

FOR SCIENCE EXPERTS ONLY

Can you explain this science contradiction?
In the winter you blow on your hands to make them warm. When you burn your finger you blow on it to cool it off.

Answers to Brain-Boosters appearing in the last issue

Mystery Photo: The rock came from the floor of the cave. What shape would it have been if it were from the roof?

Can You Do It? It is difficult to blow the paper ball into the bottle, but sometimes it can be done by blowing softly.

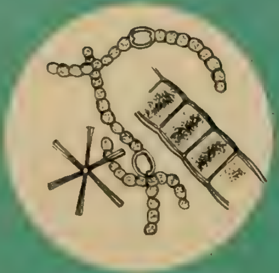
What Would Happen If...? The acid in vinegar softens an egg shell, making it possible to bounce the egg. Can you find other things that will be softened by vinegar?

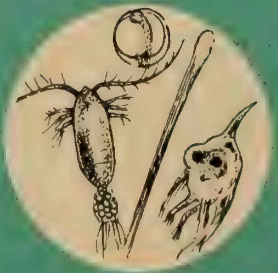
Fun with Numbers and Shapes: Each issue of *Nature and Science* has about 10,000 words. An easy way to find this out is to count the number of words on one inch of page. Then measure how many inches of words there are on all pages, and multiply.

For Science Experts Only: You can skate on ice because the ice under the blade of the skate turns into water. The water makes the ice skate slide easily over the ice. So when you ice skate what you really do is skate on water. (Don't try it in the summer, though!)

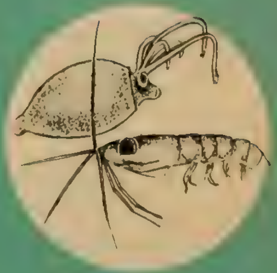
WHO EATS WHOM EATS WHOM EATS WHOM

PLANKTON—The key link in the food chain is **plankton**—billions of tiny plants and animals that drift below the surface in the ocean currents. The word "plankton" is from a Greek word meaning "wanderer."



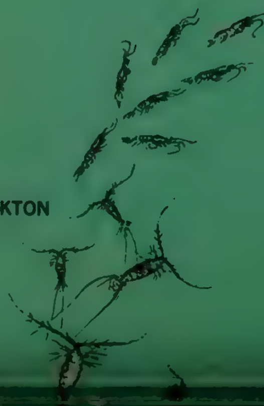


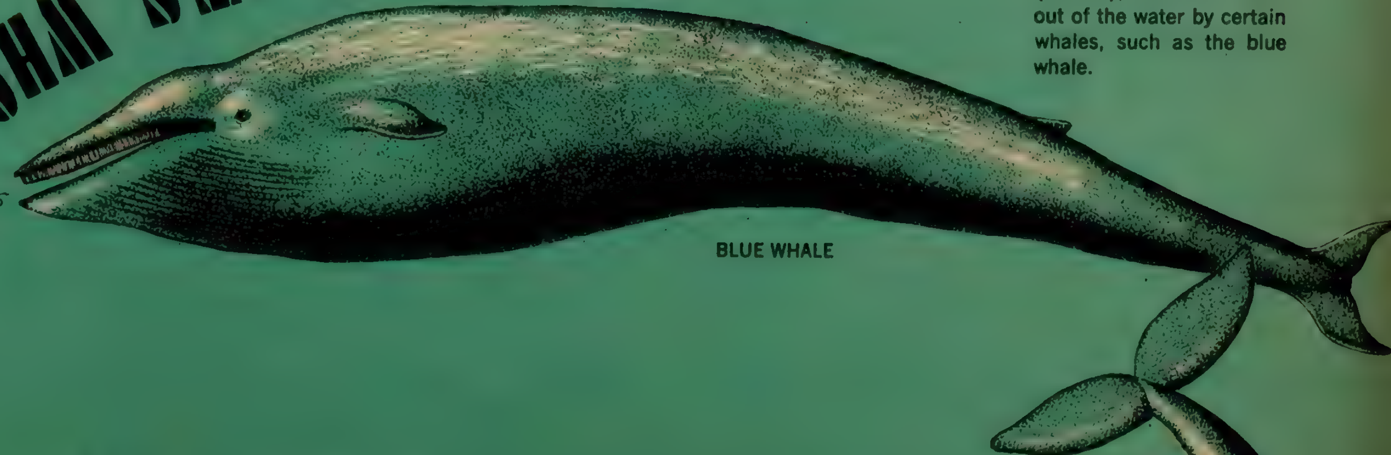
ANIMAL PLANKTON includes the young stage of crabs, arrow worm, fish egg (round object), and copepod (left). Most plankton animals eat plants but some eat other members of the animal plankton.



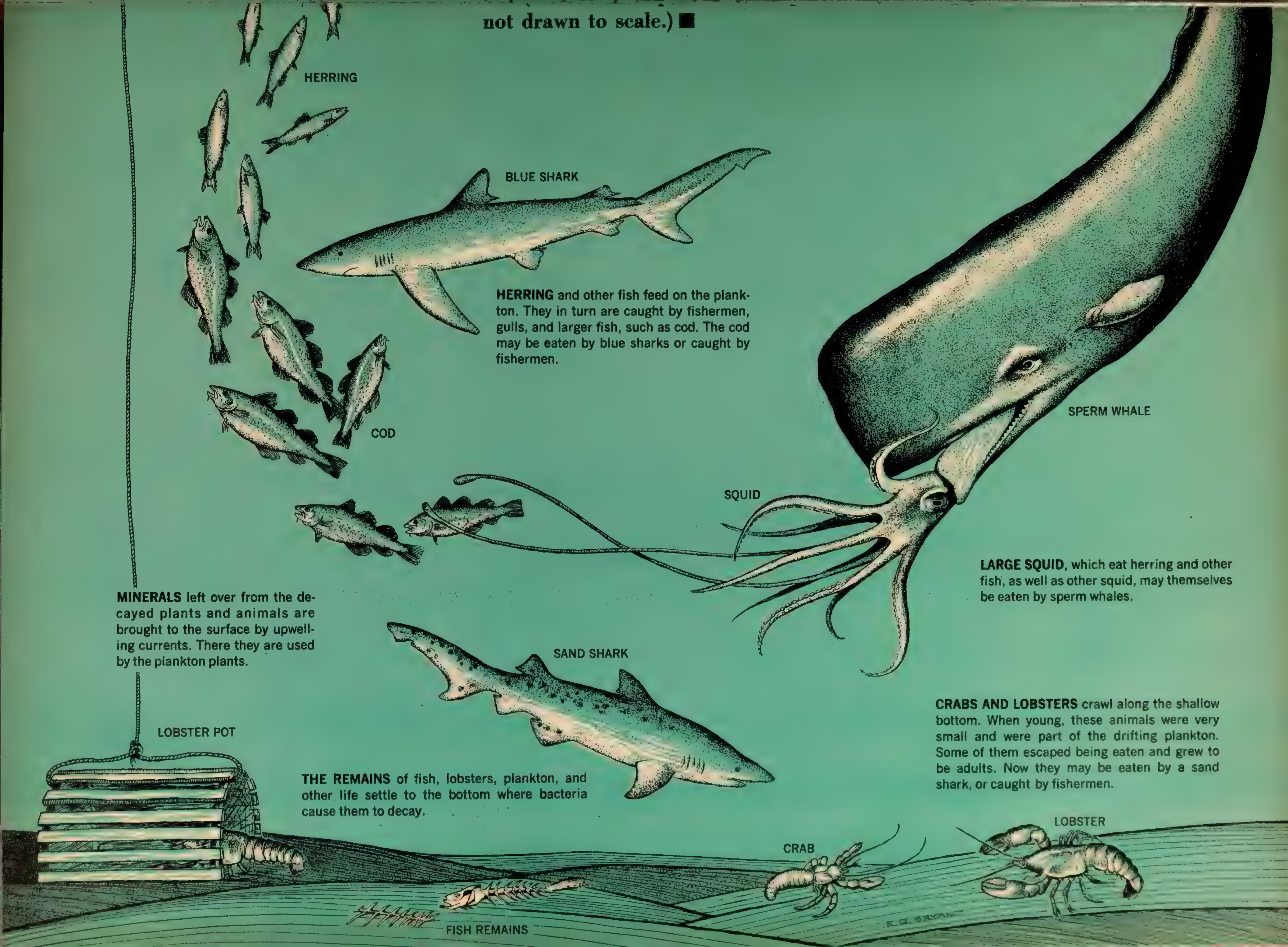
MORE ANIMAL PLANKTON includes young squid (top) and the shrimp-like **krill,** (bottom), which are sifted out of the water by certain whales, such as the blue whale.

PLANT PLANKTON includes diatoms (squares, linked squares, rods), and algae. These microscopic plants depend on the sun's energy to make use of the minerals (such as phosphates and nitrates) in the water. These plants are the main diet of many of the plankton animals.


PLANKTON


BLUE WHALE

■ **Most of the creatures in the ocean, as well as those on land, spend most of their time eating and trying to keep from being eaten. Energy passes from one to** not drawn to scale.) ■



HERRING
BLUE SHARK
COD
SPERM WHALE
SQUID
SAND SHARK
LOBSTER POT
CRAB
LOBSTER
FISH REMAINS
R. G. BRYANT

HERRING and other fish feed on the plankton. They in turn are caught by fishermen, gulls, and larger fish, such as cod. The cod may be eaten by blue sharks or caught by fishermen.

LARGE SQUID, which eat herring and other fish, as well as other squid, may themselves be eaten by sperm whales.

MINERALS left over from the decayed plants and animals are brought to the surface by upwelling currents. There they are used by the plankton plants.

CRABS AND LOBSTERS crawl along the shallow bottom. When young, these animals were very small and were part of the drifting plankton. Some of them escaped being eaten and grew to be adults. Now they may be eaten by a sand shark, or caught by fishermen.

THE REMAINS of fish, lobsters, plankton, and other life settle to the bottom where bacteria cause them to decay.

what's in a wave?

by Marlene Robinson

You don't have to get clobbered in the surf to learn how waves work. A fine place to begin is with a puddle.

■ First of all, go find a puddle. Then toss a small rock into it, between the center of the puddle and one end. Many things happen very quickly, and at first you may notice only patterns of the ripples. Keep tossing small rocks or pebbles until you can see the shapes of the individual small waves. They are like a parade of tiny hills moving across the puddle.

The top of each wave is called the *crest*. Between crests the water dips low, in a *trough*. If you want to know how high a wave is, you measure the distance from the trough to the crest. The length of a wave is the distance from one crest to the next one *(see Diagram 1)*. These measurements are hard to make with the tiny waves in a puddle, but you can measure the length of waves in a bathtub.

The *period* of a wave is the time it takes two crests to pass a certain point. If you are by the sea or a lake, you can measure the period of waves easily. All you have to do is count off the number of seconds between wave crests passing over a rock, or an upright stick. The period of your puddle waves will be very short (less than a second).

Drop a small stone into the far end of the puddle so that the group of waves moves the entire length of the puddle. Count the number of seconds it takes the leading waves to reach the opposite shore of the puddle. Does it make any difference if the rocks are large or small? Watch closely what happens inside each group of waves. Does any wave ever overtake and pass the one ahead? See if you can make waves with short wavelengths, then waves with long wavelengths. Which travel faster?

If a wind comes up, what happens to the calm puddle water? What kind of a wave pattern is formed?

If there isn't any wind, try fanning the water of the puddle. Try blowing hard down on the water. Are the waves formed by blowing hard different from the waves caused by fanning the water? Are they higher, longer, shorter, faster?

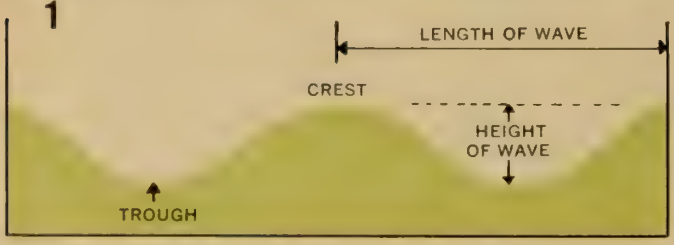
Scientists do not know *exactly* how the wind causes waves, but it does. Once the waves are started, the wind seems to push against their sides, building them higher. Energy of the wind goes into the waves, and the waves unload their energy onto the shore. Waves built up by a storm in the South Pacific Ocean have traveled 7,000 miles, breaking and unleashing their energy on the coast of California. The "gentle" swells moving toward the shore from the deep ocean are storehouses of great amounts of energy. A 135-pound rock was once hurled 90 feet into the air by a wave, smashing the roof of Tillamook lighthouse, Oregon.

Inside a Wave

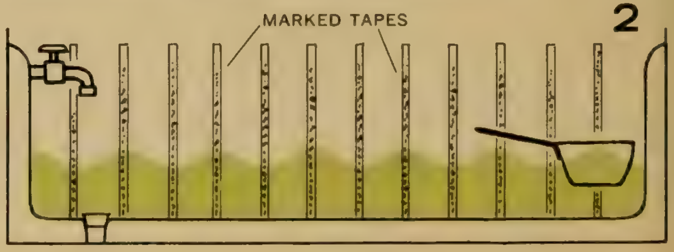
As shown in Diagram 2, stick strips of sticky tape that you can write on with colored pencils or crayons from the top to the bottom of a bathtub, every four inches apart. Beginning at the bottom of the tapes, mark the inches in red, and the half inches in blue. Make your inch numbers large and clear so you can read them quickly. Next, run water into the tub until it is 6 inches deep.

Make a wave by gently pushing the bottom of a flat pan straight down into the water at one end. Measure the crest and trough of the wave as it passes the markers. Can you measure the wavelength before a wave hits the end of the tub? Before you try to measure the wavelength, see what

The length of a wave is measured from crest to crest. The height is measured from the trough bottom to crest top.



By sticking marked tapes to the side of a bathtub, you can measure the height and the length of waves.



happens to a wave when it hits the end of the tub. It will be reflected. Is the reflected wave larger or smaller?

After the water calms down, put a cork or some other small floating object in the tub near one of the tape markers. Study the cork's motion against the side of the tub as you make waves. Does it move along with the waves at all?

[illegible]

If you have a Slinky (a long metal spring), tie one end of it to the leg of a table or chair. Stretch the other end out across the room, then make Slinky waves. Make up-and-down waves, and waves that go from side to side. Mix them up. Make as many different kinds of waves as you can and see what they do. When a wave bounces back from the table leg, can you make another wave pass through it?

The next time you go to a lake, or to the ocean, watch the mixed up pattern of waves that come into a small inlet. Try to remember if they are like your Slinky waves.

Have you ever watched a swimmer floating on the swells just beyond the breakers at the beach? First he is pulled out toward the approaching wave, then he rides up the front slope of the swell, is carried toward the shore by the wave crest, and then slides down the back slope of the wave into the trough. In other words, he moves in an up-and-down circle. Does the floating object in the bathtub move that way, or in more of an up-and-down *oval?* Do you think the depth of the water in the bathtub has anything to do with the shape of the object's path?

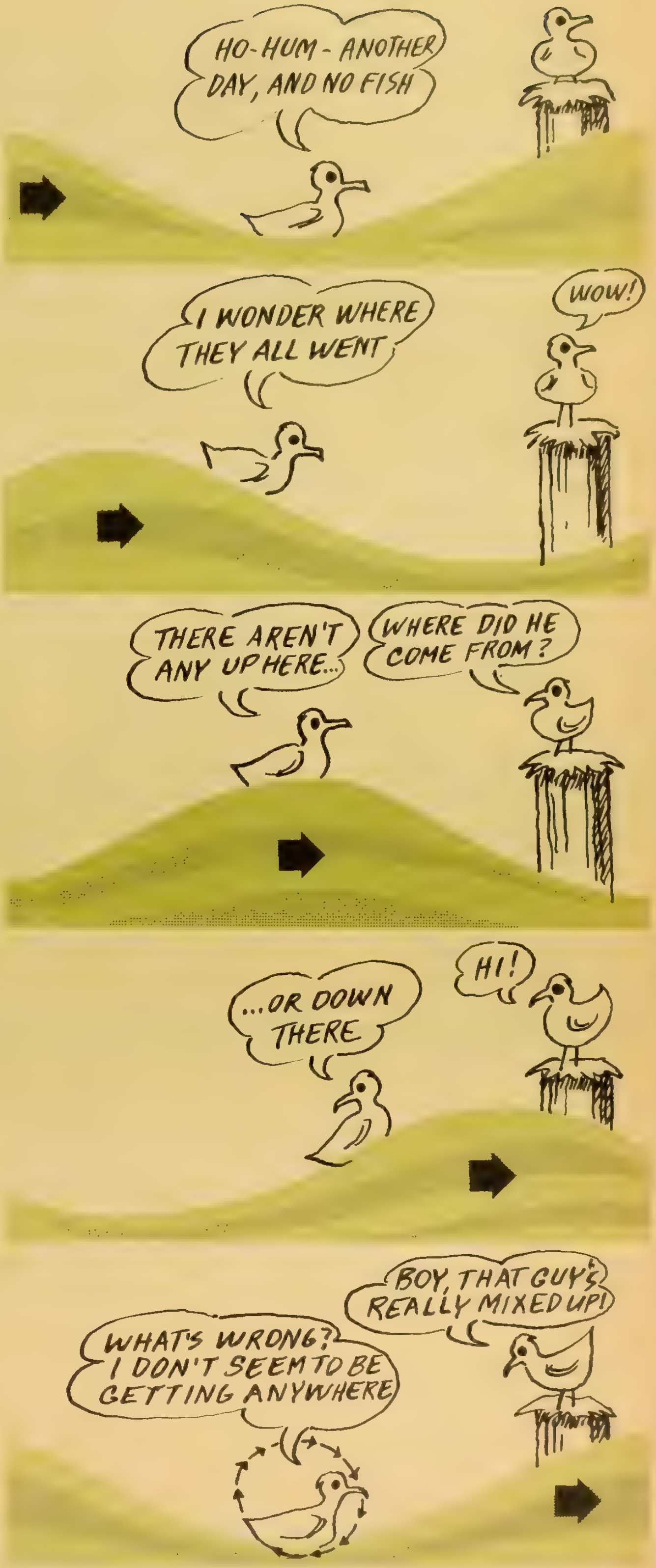
Although floating objects do move along very slowly in the direction of wave motion, most of their motion is up and down in a circle *(see Diagram 3).*

Breakers

Why don't the large "gentle" swells we see offshore reach the beach as gentle waves? Why do they develop sharp crests and tumble over as breakers? In the swells far offshore, the circular motion of the water is not held back by the sea floor. But when a swell moves into shallow water, the lower part of it begins to slow down. Because water in the upper part of the swell is moving faster than water in its lower part, the swell becomes a wave that spills over its own top as a breaker. In short, the water particles at the crest of the wave out-races the particles below. The crest bends, falls into foam, and the water is flung onto shore with the wave's stored energy.

Steep beaches make sudden, high breakers that form close to the shore. Long flat beaches bring in the slower rollers that surfers look for. Can you think why? ■

3


HO-HUM - ANOTHER DAY, AND NO FISH
I WONDER WHERE THEY ALL WENT
WOW!
THERE AREN'T ANY UP HERE...
WHERE DID HE COME FROM?
...OR DOWN THERE
HI!
BOY, THAT GUY'S REALLY MIXED UP!
WHAT'S WRONG? I DON'T SEEM TO BE GETTING ANYWHERE

Landscape of the

Here is what you would find if you took a stroll across the bottom of the ocean.

■ If someone asked you to make a map of your neighborhood, it would be pretty easy. All you would need would be a compass and a tape measure. But if you were asked to make a map of the ocean floor, what would you do? You can't drain the water out and march around with a compass. Anyway, what's down there to map? A whole lot of sand? For a long time, that is just what men thought *was* down there—a lifeless, flat expanse of sand and mud.

Nearly 200 years ago, ocean-going scientists were lowering lead-weighted lines to the sea floor to find out the depth of the ocean. One such line was four miles long.

Over the years, *oceanographers* (scientists who study the ocean) have developed new ways of probing the ocean depths. One way is to measure the time it takes sound waves to travel from a ship to the sea bottom and back to the ship *(see diagram)*. Scientists have discovered that the ocean floor is a rugged, changing landscape every bit as spectacular as the mountains, canyons, and other features on the land. If you *could* take a walk across part of the ocean bottom, here is what you might find.

On the Shelf

After you stepped through the surf, you would walk out on a gradually sloping shelf—called the *continental shelf*. You would find rocks and sand and other sediments to be very much like those on land. About 50 miles from shore, you would be between 300 and 600 feet below the water's surface, on the edge of the *continental slope*. It is the edge of the continental slope, not the shore line, that marks the true edge of the continents. The width of the continental shelves varies from place to place—from as wide as about 800 miles in the Arctic region to only a few miles wide off the west coast of North and South America.

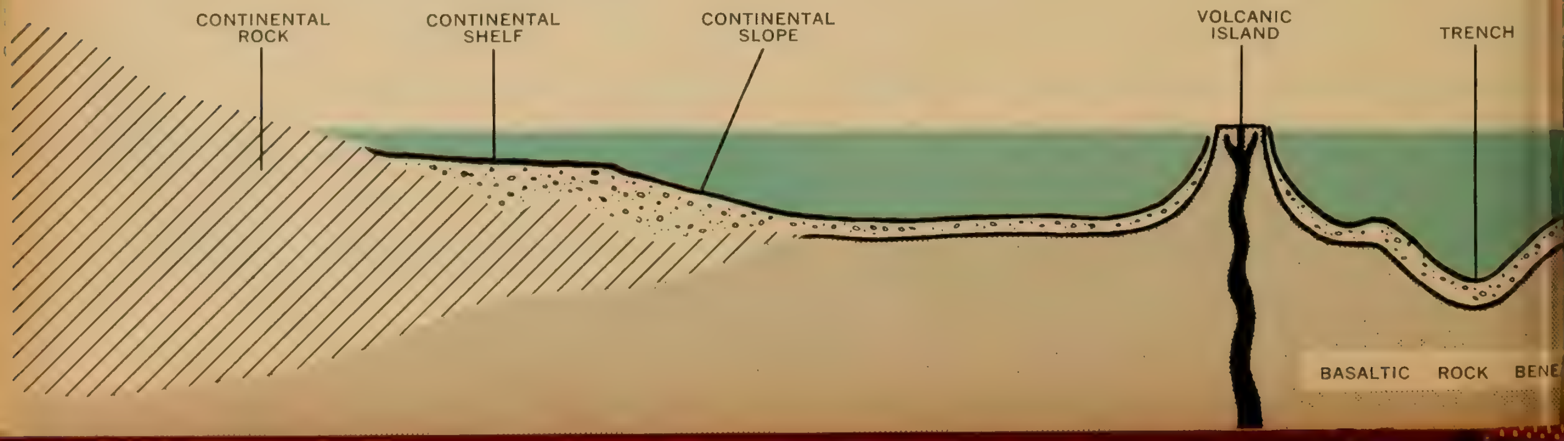
You might not be able to stay at the edge of the continental shelf very long, because strong underwater currents of mud and other sediments sometimes sweep down the slope at 50 or 60 miles an hour. These currents—called *turbidity currents*—cut great canyons in the slope and deposit their sediments far out onto the sea floor. Turbidity currents may be set in motion by undersea earthquakes.

After tumbling down the slope for a distance of 40 to 50 miles to the true floor of the sea, you would be on a vast plain stretching seaward for hundreds of miles. This is an *abyssal plain,* where sediments from the land have been washed onto the continental shelf, then down the slope, filling up vast hollows in the sea floor.

Here, at a depth of about 10,000 feet, you would be in inky gloom, far below the depth where the light from the sun reaches. You might have to walk through a rather unpleasant muddy ooze, made up mostly of billions of shells of dead microscopic animals that have sunk to the bottom over a period of millions of years. You would come across little tracks and tunnels made by worms, starfish, and other deep-sea animals.

Mountains under the Sea

Every now and then you might come across a volcanic mountain. If you climbed a few of them, you would find that some take you right up to the surface of the ocean. The peaks of such mountains form islands. In the Pacific Ocean, particularly, you would climb some ancient volcanoes and find yourself on a flat top, like a table, hundreds of feet below the surface. These are called *guyots,* and they were once islands. Their tops were worn flat by the waves at



Deep

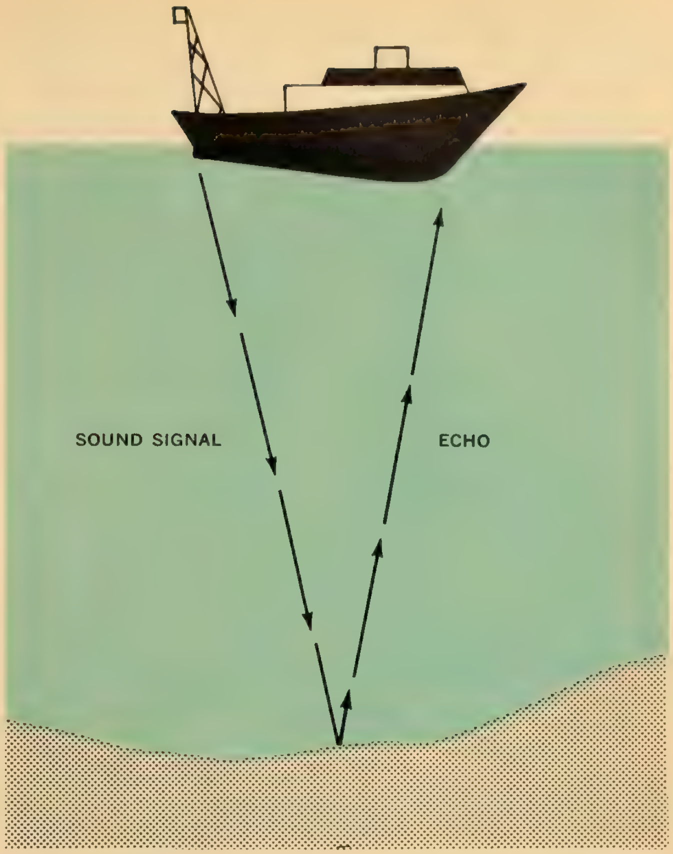
by James K. Page, Jr.

the surface, and thousands of years ago they slowly sank down below the surface.

If you were walking on the ocean bottom near Japan, you would find yourself walking down hill for mile after mile. You would continue your downhill march until you were at about twice the average depth of the ocean, into the Mariana Trench. There are a number of such trenches in the oceans, mostly in the Pacific, but the Mariana Trench, about 35,800 feet deep, is the deepest. You could fit Mount Everest in it and the peak would still be below the surface.

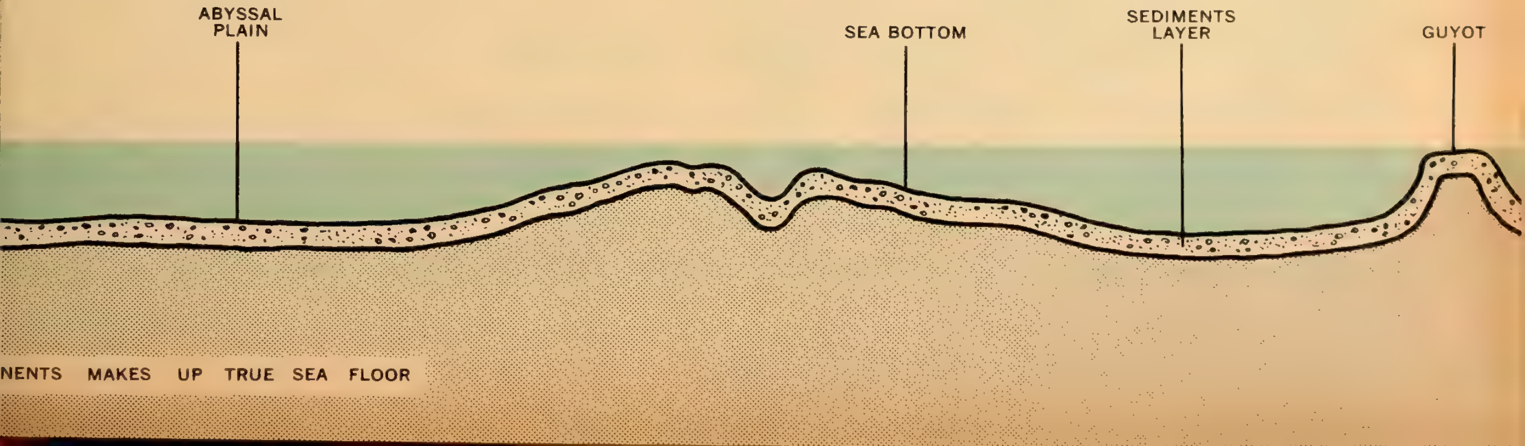
Walking across the Atlantic, you would run into a huge undersea mountain range, like a great wall in the middle of the ocean. Called the mid-Atlantic Ridge, in places it sticks up above the surface, forming the Azores and Ascension Island. Farther south, it meets other mountain ridges that extend throughout most of the oceans of the world. The mid-Atlantic Ridge is about 1,000 miles wide at its base and about 10,000 miles long. If you climbed it, you would find a steep valley, or *rift,* in the middle of it. Walking north or south in this rift, you would see that it extends the length of the ridge. It would seem like a great rip in the earth's crust, and you might think, as some scientists do, that the earth's crust is slowly splitting, as if our planet were expanding. This may be just what is happening.

Naturally, no one is ever going to take a walk like this one, but men are exploring all the areas under the seas. Men have already spent 20 minutes observing the deepest known part of the ocean floor *(see page 6),* and oceanographers are constantly exploring the ocean bottom with echo-sounders and other devices. As with today's explorers of outer space, oceanographers are also bringing us exciting information about a world beyond the reach of most of us ■



The echo-sounder is an instrument that sends out sound signals in the form of "pings," one every second or so. The length of time it takes a ping to reach the sea bottom and then bounce back to the ship as an echo tells scientists exactly how deep the water is beneath the ship. As the ship moves along, the echo-sounder draws a continuous line on a moving piece of paper. The line shows the profile, or shape, of the sea bottom.

If you could stroll across the bottom of the sea, you would first walk out onto the continental shelf, then down the slope to the sea bottom. Vast flat areas (abyssal plains) make up much of the sea floor. There are also active volcanoes, some of which stick up above the sea surface and form islands. Sediments of sand, mud, and other materials wash off the land areas and cover the sea floor.



THE DEADLY WORLD of SHARKS

by James W. Atz

Why do sharks kill some swimmers and leave others alone?

■ The pilot jumped from his burning plane and pulled the ripcord of his parachute. It was 1943, and his plane had been damaged in an attack on a Japanese-held island. As he floated down toward the dark Pacific Ocean, he thought of many things: his life raft . . . his food supply . . . his chances for a quick rescue. But most of all, he thought of sharks.

Why worry about sharks? "The Shark Is a Sissy," claimed an article in a national magazine in 1944. This may be true—of some sharks. After all, there are about 250 known kinds *(species)* of sharks. Some species are only about a foot long. And some of the biggest sharks have small blunt teeth and eat only small fish and animals called *plankton (see pages 8 and 9).*

There is no doubt, however, that some species of sharks can be man-killers. For example, between 1958 and 1963, 31 people were attacked by sharks in waters around the United States. In Australia, more than 170 people have been attacked since 1919. Even there, though, sharks are no major threat to man. The late Dr. V. M. Coppleson, an Australian who was one of the world's authorities on shark attack, said: "The idea that the sea is full of savage sharks swimming around seeking what humans they may devour has little support to it. In fact, death by shark bite, while grotesquely spectacular, is an uncommon cause of death in Australia. The risk is less than walking across a road or playing cricket or football."

Dr. James W. Atz is Associate Curator of Ichthyology at The American Museum of Natural History.

Shark Chaser

Still, people have a terrible fear of sharks. The United States Navy discovered this during World War II when it began sending men on long flights over lonely, shark-infested oceans. Facing the enemy was one thing; fear of being forced down in such waters was quite another. To meet this morale problem, the Navy developed *Shark*

Chaser, a small cake of chemicals that dissolved slowly when put in sea water. As soon as a downed flyer spotted a shark, he removed the cake from its waterproof envelope and dangled it in the water on a tape. An inky cloud spread through the water.

Shark Chaser certainly gave confidence to the men in the water. But just how well it repelled sharks is still in doubt. It had to be developed in a hurry and could be tested on only a few kinds of sharks and under certain conditions. A real study of sharks and their behavior was needed, and the Office of Naval Research turned to the American Institute of Biological Sciences for help. In 1958, a Shark Research Panel of scientists was set up to begin a worldwide program of shark study. Their goal is a better understanding of the behavior and biology of sharks. They hope that this information may lead to a solution to the shark attack problem.

The leader of the Shark Research Panel is Dr. Perry W. Gilbert, Professor of Zoology at Cornell University in Ithaca, New York. His office is a headquarters for the shark study. On one side of the room is a huge cabinet filled with shark teeth and pieces of shark skin. Each is carefully labeled. Very few of the sharks that have attacked people have been identified, and these teeth and bits of skin are important clues. Shark's teeth sometimes break off in a wound, and some species of sharks can be identified by their teeth. Dr. Gilbert is also collecting the jaws of sharks and photographs of wounds caused by sharks. Some day it may be possible to identify sharks by the wounds they cause.

Lining the walls of the office are shelf upon shelf of books and scientific papers about sharks. Near Dr. Gilbert's desk is a green filing cabinet that holds records of every known shark attack. A second set of these records is kept by Dr. Leonard P. Schultz of the U.S. National Museum in Washington, D.C. As soon as Dr. Gilbert or Dr. Schultz learns of a shark attack, he gets in touch with a scientist in the area, who then gathers all the information he can about the attack.

Sometime in the future, when the green filing cabinet is much fuller than it is now, a study of shark attacks over the years may reveal some regular pattern in these attacks. Then we may be able to predict under what conditions shark attacks are most likely to occur, and so avoid them. So far, shark attacks show no definite pattern, although scientists have learned a few things about what sharks *often*—but not always—do.

A Taste for Human Beings

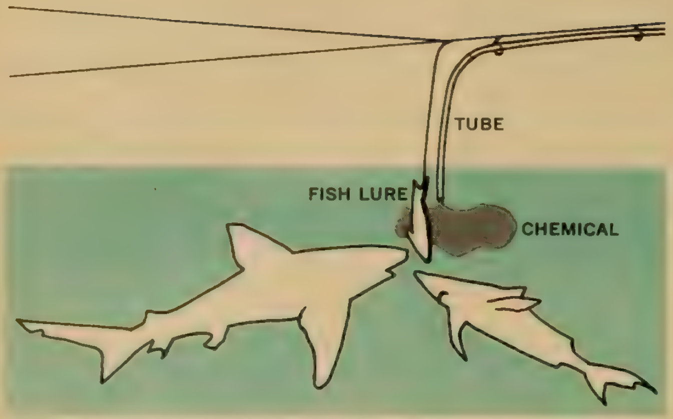
For example, we know that blood in the water seems to attract sharks and put them in a feeding mood. Similarly, spearfishermen are learning that any dead fish they tie to their belts often makes them the center of attraction for sharks. Also, once a shark attack has occurred, the chances of more attacks in the same area are high.

This fact may be explained by the "rogue shark" theory—that is, that one shark may develop the habit of feeding on human beings. The best example of such a shark was the 8½-foot white shark that terrorized the New Jersey coast in the summer of 1916. Within 10 days shark attacks killed four people and seriously injured another. Two days later a shark was caught not far away, and in its stomach were found human flesh and bones. No more attacks occurred after this.

One of the New Jersey attacks was unusual in that the shark's fourth victim was killed while trying to rescue its third victim. This is one of the few cases in which a rescuer has been attacked by the attacking shark. Incredible, yet

(Continued on the next page)

The photo above shows Dr. Gilbert examining the eye of a mako shark. To learn about shark eyesight, movies are taken of captive sharks feeding and swimming. Then the sharks are temporarily blinded with plastic shields (below), and photographed in action again. By comparing the films, scientists get an idea of how sharks use their eyes.



To test chemicals that might repel sharks, a fish is hung in the water of a shark pen (above). Then a chemical is put into the water flowing through a tube near the lure, and observers watch to see how the sharks react.

The Deadly World of Sharks (continued)

carefully checked, stories have been told of sharks returning to strike their human prey again and again but not harming nearby swimmers who were trying to save the injured bather. It seems that sharks can accurately locate their prey, even in confusing situations.

Beyond a few facts and theories, very little is known about the feeding behavior of sharks, or about shark behavior in general. This is a situation that the Shark Research Panel has set out to change.

An important first step is to study the sense organs of the shark. Then we will have an idea of what a shark's world is like—to a shark. We do know that sharks are "smell-minded." Smell is the most important sense by which sharks find out what is going on in their world. However, some big questions remain. How sensitive is a shark's sense of smell? What chemicals attract sharks? Which ones repel them? Answers to these questions may come from studies going on at the Lerner Marine Laboratory, a field station of The American Museum of Natural History. The lab is located in Bimini (two islands in the Atlantic Ocean south of Florida).

Clues from Rotten Shark Meat

Special pens have been built in the shallow, clear waters at the Museum's Lerner Marine Lab. Sharks kept in these pens can be easily observed or taken from the water for experiments on their sense organs. Different kinds of chemicals, foods, and body fluids (such as blood) are put into the water to find out which ones attract sharks and which repel them.

In these studies, special attention is given to the different substances in rotten shark flesh. It seems that some species of sharks are repelled by the smell of this rotten meat. Of course, it isn't practical for every ocean swimmer to carry a chunk of rotten shark meat along. Scientists are trying to discover which of the hundreds of substances in rotting shark meat are the ones, or one, that keep sharks away.

Some people may give off substances—in their sweat, for example—that make them especially attractive to sharks. Or, on the other hand, they may *lack* a substance that keeps sharks from other people. Dr. Gilbert suggests that some day swimmers, divers, and pilots may be able to take a pill that makes them smell bad to sharks.

There are also great gaps in our knowledge of what sharks can see. At one time sharks' eyes were believed to be of little use, but Dr. Gilbert has found that their eyes are very sensitive. They are not very good at seeing fine detail, but can easily detect differences in light and darkness. This may explain why sharks are attracted to light or shiny objects. (Some dark-skinned divers hide the soles of their feet with black sandals before going into the water.) This may also explain why a shark attacked only the hands of a man who spent 18 hours in the Atlantic, clinging to a life-preserver from his sunken boat.

What about other senses? Spearfishermen have noticed that sharks sometimes suddenly appear as a speared fish struggles in the water. The fish may not be bleeding, or at least there has not been enough time for the blood to spread far in the water. Undoubtedly, sharks can detect vibrations in the water caused by a struggling fish. And what about the sharks hearing? Divers have been able to drive sharks away by shouting at them underwater. Some sounds, however, attract sharks. The effects that underwater sounds and vibrations have on sharks is now being investigated.

In trying to find out what causes sharks to attack men, the shark investigators are studying harmless sharks as well as dangerous ones. They are also getting clues from studies of other kinds of fishes. There is much more involved in a study of shark behavior than the attacks themselves. No one knows just where some piece of information will turn up that will help solve the problem of the deadly sharks ■

???? A PUZZLER ????

More shark attacks on humans take place in the afternoon than at any other time. Yet studies have shown that sharks are most active at night. How would you explain the many afternoon shark attacks?

Using This Issue...

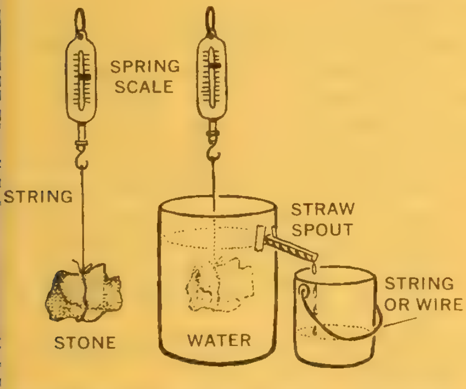
(continued from page 2T)

less," like a capsule or an astronaut in orbit, but it weighs less than when it is out of water *(see Activity below)*. Because of this, an aquanaut can move his body or lift things with less effort underwater than when he is out of water.

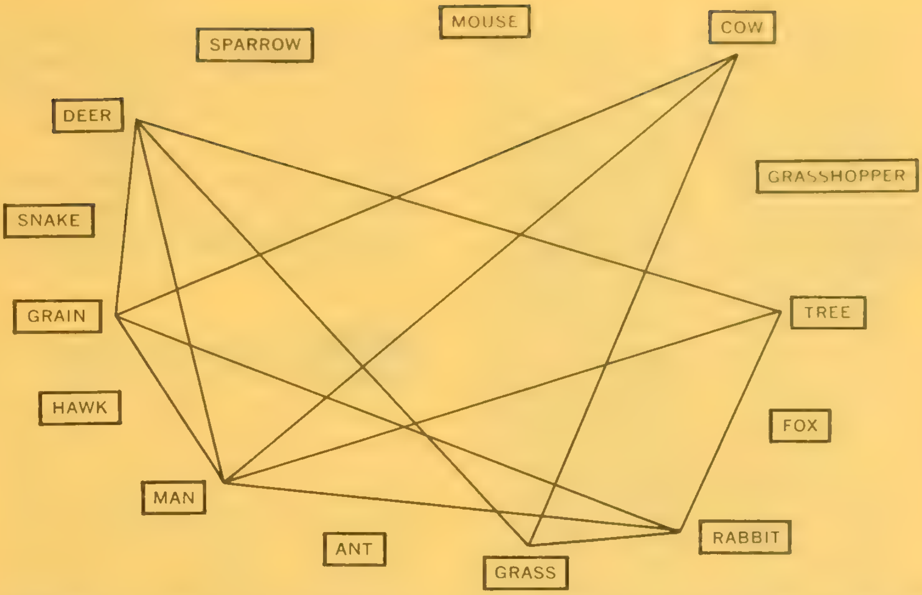
- *Why did psychologists study the behavior of the aquanauts via closed-circuit TV?* The question of how well men get along with each other when they are confined to a small area and isolated from others over long periods of time is important because these are the conditions that will exist in manned space stations as well as undersea laboratories. Also, skin divers have been known to get a feeling called "rapture of the deep," a state of euphoria, or false feeling of well-being. In such a state, divers have been known to behave erratically, for example, removing their masks.

Activity

An object immersed in a liquid is buoyed up, or "loses weight" equal to the weight of the liquid it displaces. Your pupils can test this with the equipment shown in the accompanying diagram. The large container should be filled right to the spout with water. 1.Weigh the can, then set it under the spout of the cup. 2. Weigh the stone, suspended from the scale with a string. 3. Lower the stone slowly into the cup until it is covered by water and take its weight. 4. Weigh the can of displaced water and subtract its weight when empty. The weight of the displaced water should equal the apparent loss of weight of the stone when immersed in water.



Equipment for testing loss of weight of an object immersed in a liquid. You can use paper or plastic containers and half of a large soda straw for the spout. Cut ¼-inch slits in one end of straw, spread flaps inside hole, and fasten flaps to wall with sticky tape. Drip candle wax around outside of hole to seal spout.



This diagram shows only one chain in the "web of life." It traces the food energy of man back to the green plants that support nearly all life. The web becomes more complex as lines are drawn to trace back the food energy of hawks, snakes, foxes, and other animals shown in the diagram.

PAGE 8 Who Eats Whom

This Wall Chart shows an example of the great chain of life in the sea. Emphasize to your pupils the interdependence of the various groups of organisms. Draw analogies to food chains on land, especially man's dependence on energy that comes directly from land plants and indirectly —through animals—from land and water plants.

Phytoplankton *(phyto* means "plant") are essential to the animals of the sea. Almost all areas of the oceans have planktonic plants and animals, but some areas are better suited for their growth than others. These areas are usually the best fishing areas.

A large planktonic population is usually found where there is an abundant supply of phosphates (all forms of life require some phosphorous for healthy growth). Phytoplankton rapidly exhaust the phosphate and other mineral supplies near the surface. A combination of adequate sunlight and upwelling currents from the ocean floor, which carries phosphates from decayed bones of dead fish and other minerals from the sediments on the ocean bottom, encourages a large crop of phytoplankton.

You might point out to your pupils that plankton are not exclusively marine. Food chains in fresh water ponds, lakes, and streams are also dependent on tiny plants and animals.

Activities

- Have your pupils try to work out food chains for your area. Perhaps you could assign each child the name of an animal that is found locally and have him find out what the animal eats and what eats it. Have them trace the chain back to its origin—usually either living or dead plant material.
- Another way to emphasize the interdependence of all life is to set up a "classroom food chain." Using the material gathered in the activity above, have the children make small signs so that each child has a label, such as fox, rabbit, mouse, grasshopper, grass, grain, and so on. Then join the links in the various food chains with lengths of string. For example, there would be a string running from man to cow to grass, and from hawk to snake to mouse to grass and grain *(see diagram)*. This will illustrate the interdependence of all living things and emphasize the importance of plants. Then ask: Where do plants get their food energy? Add soil, water, and sunlight to the chains and you will have a maze of strings that will make an important point.

Reference

"Food Chains," Cornell Science Leaflet, Vol. 55, No. 4, 32 pp., 25

(Continued on page 4T)

Using This Issue...
(continued from page 3T)

cents. Available from Cornell Science Leaflets. Stone Hall, Cornell University, Ithaca, N.Y.

10 Waves

There are many kinds of waves in the ocean, and they differ greatly in form, velocity, and origin. The most common kinds of waves are those caused by the wind. Have your pupils try to think of some other things that raise waves—for example, ships moving through the water, undersea landslides or earthquakes, and tides.

Waves that are started by a landslide or earthquake are mistakenly called "tidal waves"; the scientific name for such waves is *tsunami.* The tsunami is a group of three or four waves with a very long wavelength—three miles or more. They travel as fast as 500 miles per hour through thousands of miles of open sea, where they are only a foot or so high and cause no damage. When they reach a seacoast, the rising bottom slows the front of the wave down to about 50 miles an hour and the water behind piles up to heights of 100 feet or more. The wave crashes onto the shore, destroying everything in its path.

True tidal waves are the waves caused by the rhythmic rising and dropping of the sea in response to gravitational pull from the sun and the moon.

14 World of Sharks

Humans have a morbid fascination for sharks and snakes that is far out of proportion to the danger from these animals. This article describes a cooperative research effort and some of its results in a study of sharks, giving some insight into how scientists go about studying an animal and interpreting evidence.

The "puzzler" on page 16 offers your pupils a chance to do some critical thinking. Why the apparent contradiction between shark attacks and their time of greatest activity? The answer lies in people, not sharks. Most people swim in the afternoon. Very few swim at night, so there are considerably fewer attacks at night.

In an ironic sense, the pattern of shark attacks on humans is tied to the food chain in the ocean *(see* WALL CHART). Dr. V. M. Coppleson, the late Australian expert on shark attacks, found that many occurred after heavy rains washed debris from the land into the ocean. This flood refuse attracts a chain of fish and other sea creatures, beginning with plankton. At the last link in the chain are the ravenous sharks. Thus humans may inadvertently become part of a food chain.

The last paragraph of the article expresses an idea that is worth emphasizing to your pupils. A technique or an idea that is useful in studying sharks may come from research that is far removed from "killer" sharks—studies of harmless species, other fish, other animals. Your pupils can probably think of other instances like this in science, for example, the use of experiments on mice and monkeys to study human diseases. Children can use this approach of comparing the known with the unknown in their own investigations.

nature and science
EYE TO EYE WITH A FLY

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TEACHER'S EDITION
VOL. 3 NO. 8 / JANUARY 10, 1966 / SECTION 1 OF TWO SECTIONS
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Can You Disappear?

by Brenda Lansdown

■ If someone asked you to sketch a classroom, how would you draw it? Why not do it now, just for fun, before reading further?

• • •

Did you draw desks? Were they in rows, in a circle, small clusters? Did you sketch figures—even stick figures—of children absorbed in an occupation at a table? Or were the children interacting with each other, discussing, dramatizing, or working with *things* cooperatively?

Where did you put the teacher? Did you include him at all? Above all, what is the point of focus in your room—children, desks, teacher, work?

Wherever you put the teacher—or whether you included him in the picture at all—let's consider for a moment a special role for a teacher in a science classroom: the teacher who disappears from the front of the room while the children *learn* science.

Why Disappear?

It's not as hard as it may sound to one who hasn't acquired the habit. And it's not an invitation to disorder either. How can we be sure that children are learning if the teacher is not up front directing the children? We can't be really sure that each child *is* learning when we are up front. We are sure only that they are not rioting! But if each child is absorbed in some occupation, the chances are much greater that he *is* learning, especially if he is engaged in self-directed activity. After all, learning that is self-motivated is deep learning indeed. The problem is largely one of finding something intriguing and worthwhile to stimulate this self-motivated learning. Long ago I discovered that I couldn't stand the competition of a snake in my classroom, so I decided to provide a snake for each group of four or five children. A snake and children interacting provide for much science learning.

I discovered too that a white powder and a colorless liquid that fizzed when they were put together were more interesting to every child than a teacher in front of the class could ever be, even when he was fizzing up sodium bicarbonate with vinegar.

A large plastic box, two thirds full of water, with a number of small objects beside it—objects that sink, or float, or do both, or can be made to do either—held the attention of children in a summer playground so that they did not heed the arrival of the ice cream man who clanged to a stop right by them.

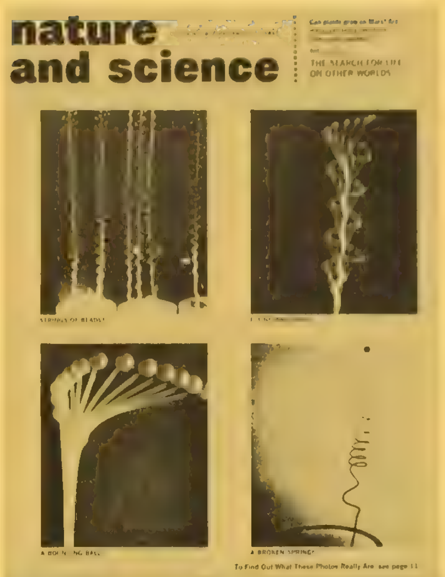
Disappearing from the front of the room is easy if suitable materials are placed within easy reach of small groups of children.

What Are "Suitable" Materials?

One of the keys to self-motivated learning in science is the use of "structured" materials, i.e., materials which when manipulated freely can lead the experimenter to a group of related facts or ideas. We are lucky to be in an era when much research is making these materials available. The Elementary Science Study Project of Educational Services Incorporated (108 Water Street, Watertown, Mass. 02172) has produced a number of units describing sets of intriguing things that lead children to discover important scientific principles as they experiment freely and watch the inter-

(Continued on page 4T)

Brenda Lansdown is an Associate Professor of Education at Brooklyn College of The City University of New York. Classroom anecdotes in this article were supplied by these teachers: Paul Jodoin, Mimi Staelin, Maxine Hymowech.



nature and science
THE SEARCH FOR LIFE ON OTHER WORLDS
STRINGS OF BEADS?
A BOUNCING BALL
A BROKEN SPRING?
To Find Out What These Photos Really Are, see page 11

IN THIS ISSUE

(For classroom use of articles preceded by ●, see pages 2T and 3T.)

● **The Search for Life on Other Worlds**
An evaluation of what is known about the environment of other planets reveals little chance for life as we know it.

My, What Big Eyes You Have!
The fact that the pupils of the eye expand and contract with a person's interest and feelings has opened a new field for the study of the human mind.

● **What Holds Them Up?**
Your pupils can look for examples of the basic building principles shown in this WALL CHART.

● **How Does Light Bend Plants?**
Botanists have learned some things about why plants bend toward light. With colored cellophane and corn seedlings, your pupils can test the effects of colored light on plants.

● **Who Ever Heard of a White Crow?**
How albinos come about and why they are seldom seen in the wild.

● **Case of the Vanishing Salt**
By mixing and separating some common substances, your pupils can discover the differences between mechanical mixtures and solutions.

IN THE NEXT ISSUE

How to make a simple electric motor . . . The adventures of Captain Cook . . . Further explorations with a microscope . . . A WALL CHART showing the evolution of the horse . . . How to help remedy the bird housing shortage.

USING THIS ISSUE OF NATURE AND SCIENCE IN YOUR CLASSROOM

2 Other Worlds

The exploration of space has been one of man's dreams for centuries. As our knowledge about the solar system, our home galaxy, and the myriad stars and galaxies beyond has increased, our questions about the possibility of life elsewhere in the universe have become more sophisticated. The idea that life, in some form, may exist on the planets of other solar systems will continue to bait man's curiosity.

Topic for Classroom Discussion

How would you communicate with intelligent life on another planet? What *kind* of message would you send? To begin with, the message would be easier to decode if it were cast in a "universal language," such as a pattern of numbers which could be transmitted as a series of radio pulses. Any form of life intelligent enough, and technologically advanced enough, to communicate with us would probably have a system of mathematics sufficiently advanced to enable them to decode a numerical or mathematical message.

For example, we might send radio pulses like this: . ..., etc., (1, 3, 5, 7). If we received a reply of .. .. (2, 4, 6) we would know that it was not random radio noise, and could then move on to a more complex concept—*pi*, for instance. To illustrate this concept of the "universality" of *pi* to your class, have them measure with a string the circumference and diameter of several round objects in the classroom—a ball, clockface, bottom of a wastepaper basket. They will discover that regardless of the object they measure, the circumference is 3 and a fraction times greater than the diameter of the object measured.

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Conditions for "Human" Life?

In the Dec. 20, 1965 issue of *N&S*, (page 2T) some of the conditions required to support human life were cited. Oxygen supply, temperature, and atmospheric pressure are three conditions which were mentioned.

Astronauts who journey into space are protected from the hostile environment beyond the earth's atmosphere by their space suits and space capsules, which provide them with a closed ecological system within which the various life-supporting conditions can be controlled. Manned exploration of the surface of the moon, Mars, and other planets within the solar system would require the same kind of controlled environment, since conditions on the other planets are radically different from those on the earth.

Activity

Have your pupils use the school library (and this issue of *N&S*) and make a chart that compares and differentiates the following conditions on the nine planets of the Solar System: 1. atmospheric composition; 2. temperature (surface or cloud top); 3. mean distance from the sun; 4. period of rotation; 5. period of revolution; 6. surface gravity. (Recommended sources: *Captives of the Sun*, by James S. Pickering, Astronomy Highlights, The Natural History Press; *Exploring the Planets*, by Roy A. Gallant, Doubleday; *The Nine Planets*, by Franklyn M. Branley, Crowell.)

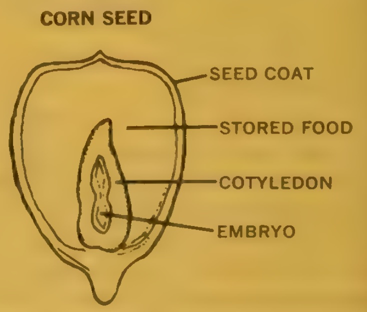
8 What Holds?

The Wall Chart in this issue of *N&S* brings to the attention of your pupils some of the problems of structure and construction which are usually taken for granted about buildings. To help your pupils become aware of certain principles underlying the design and construction of buildings, you might do the following things:

- Ask the head custodian to explain to the class the basic construction of your school. (Show him the Wall Chart first, so that he will not be tempted to go into unnecessary and confusing detail.)
- Ask your pupils to try to identify principles described in "What Holds Them Up?" in the school, their homes, or apartment building.
- On the way to and from school, they may also see many of the things described in the article. What is the most commonly used structural principle they see in their neighborhood? In the downtown area?

10 Light and Plants

- The author suggests that when planting the corn seeds, the seed should be set into the pot pointed end down. This will insure that the root section is at the bottom part of the seed, and that the shoot section is at the top. In a separate pot, plant several corn seeds with the pointed end *up*. After three or four days, when shoots appear, remove the seeds from the soil to see how the root section has turned.
- Your pupils are likely to express some interest in the composition of the corn seeds they will be working with. The corn seed consists of three main parts; the protective seed coat, the stored food section, and the embryo. To show the parts of the corn seed, carefully remove the outer coating from the kernel and note the parts



- The plant hormone auxin is available from biological supply houses *(see list on page 3T)*. Try putting auxin (diluted with gelatin or lanolin) on the end of coleoptiles after the tips have been cut off. Be sure to have a potful of control seedlings (with tips cut off but no auxin added) with which to compare the others.

13 White Crow

Albinism is an inability of certain

(Continued on page 3T)

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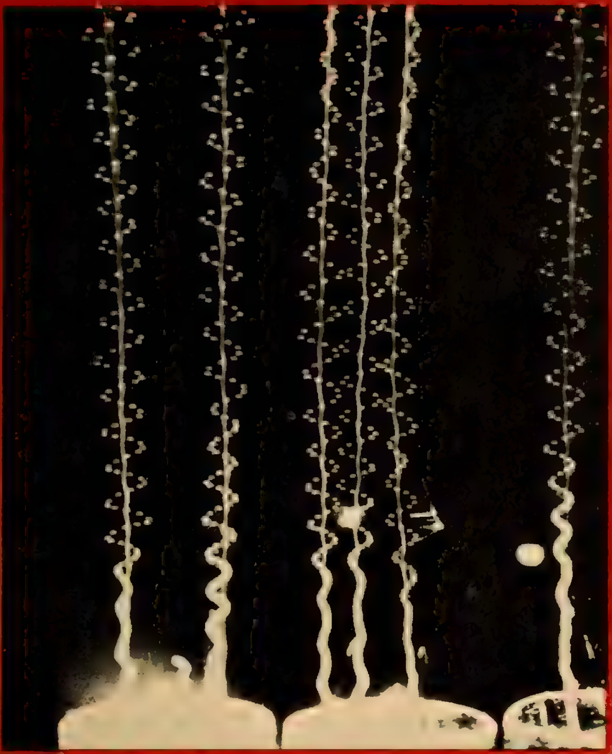
Can plants grow on Mars? Are messages being sent from other solar systems?

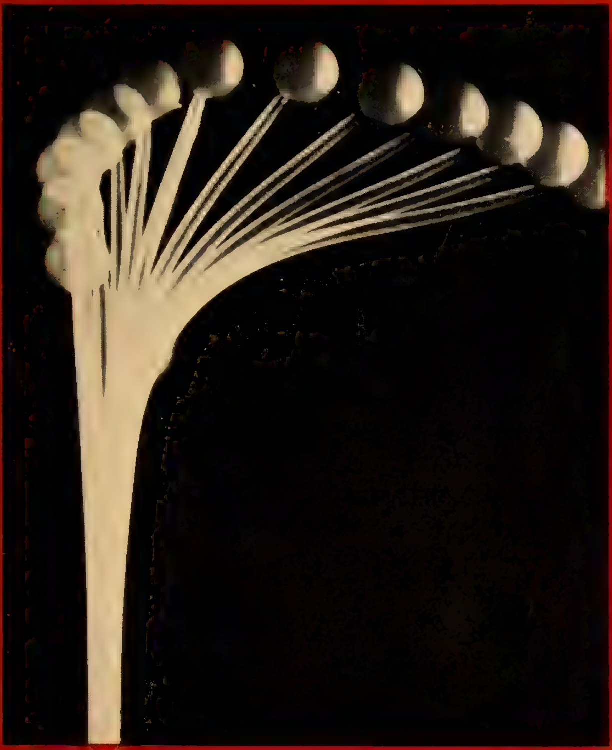
see page 2

THE SEARCH FOR LIFE ON OTHER WORLDS

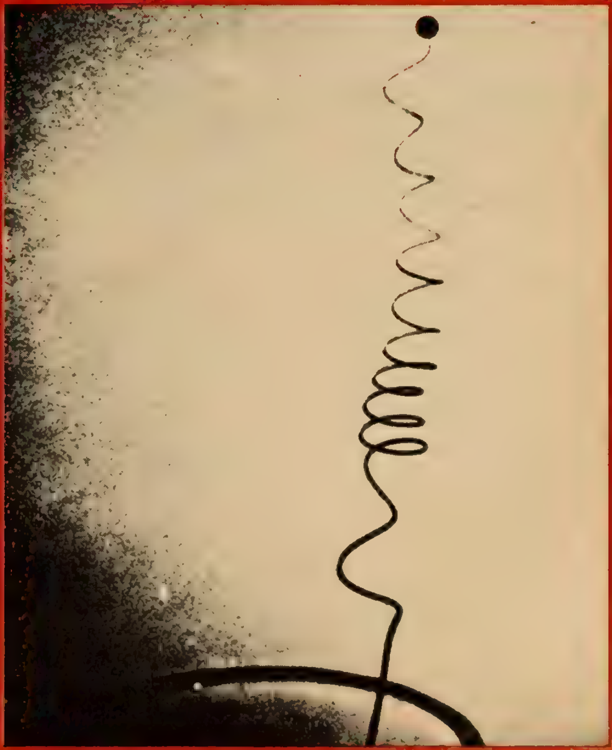


STRINGS OF BEADS?

FLYING BALLOONS?



A BOUNCING BALL?



A BROKEN SPRING?

To Find Out What These Photos Really Are, see page 11.

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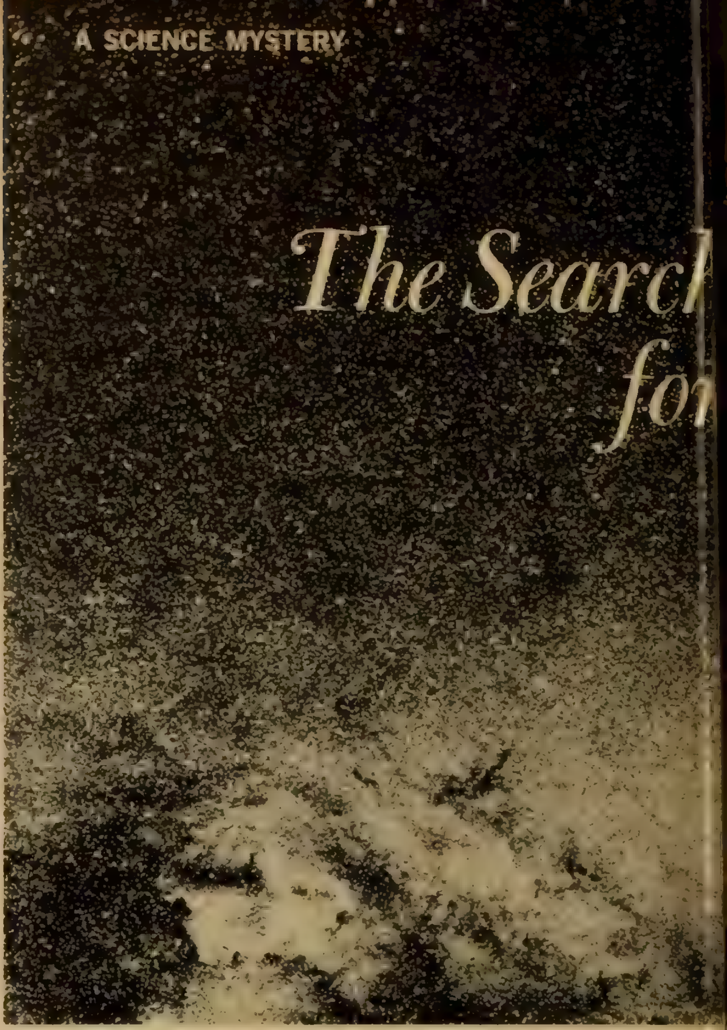
A SCIENCE MYSTERY

The Searc fo

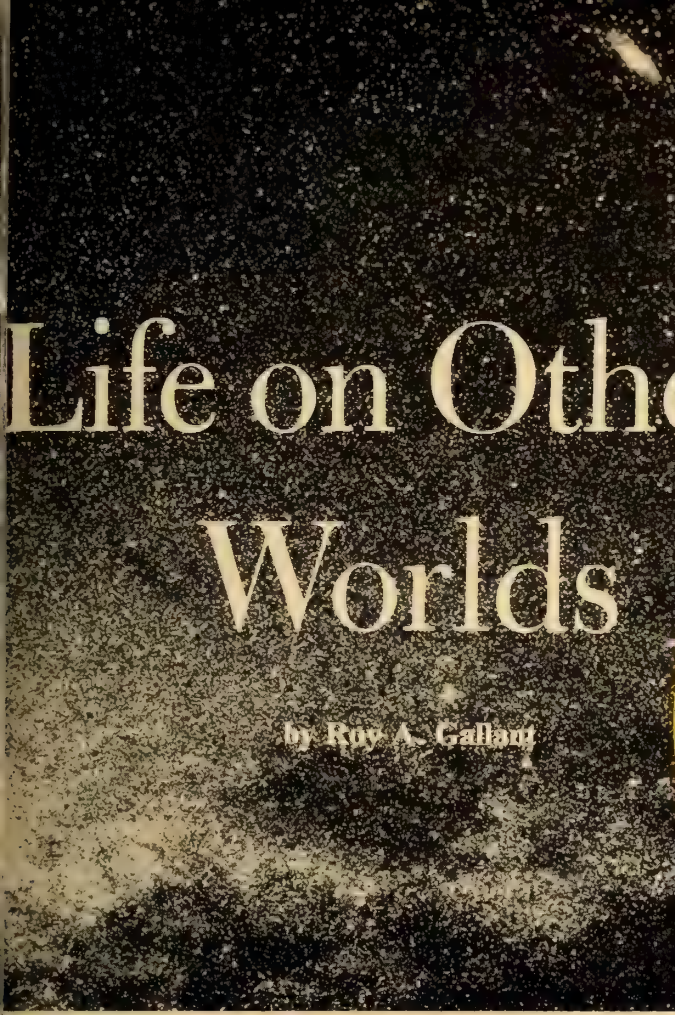


■ The time is about 4 A.M., April 8, 1960. The place i the radio telescope observatory, Green Bank, West Virginia. The 85-foot dish antenna of the telescope swings slowly on its mount until it is pointing at Tau Ceti, a sta about 60,000,000,000,000 miles away.

Operators of the telescope are listening for radio signals —coded messages—that might be coming from intelligen beings on one of Tau Ceti's planets. But there are three BIG questions: 1. *Does* Tau Ceti have planets? 2. If it does, is there intelligent life on one or more of them? 3. If there is, is it advanced enough to send radio signals across billions of miles of space?

The telescope follows Tau Ceti across the sky until the star sets below the mountainous horizon. Then the instrument swings toward another star, Epsilon Eridani, also about 10 light-years away. It "tunes in" on that star, too, and follows it until it sets. (One light-year equals about 6,000,000,000,000 miles.)

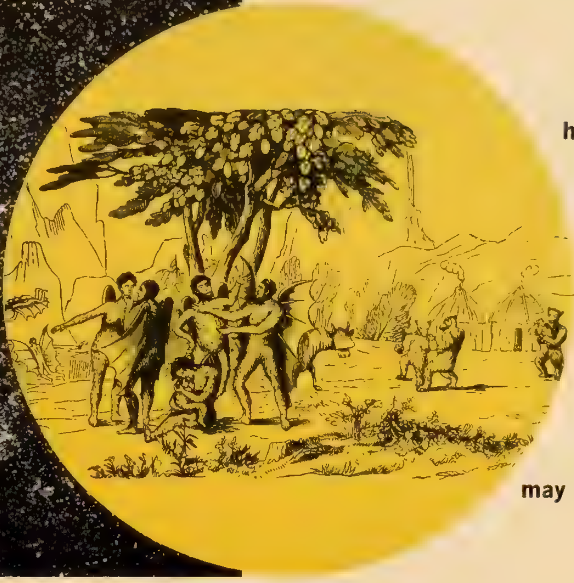
Astronomers operating the telescope "listened" to the two stars for a total of about 150 hours in May, June, and July, but they did not hear anything they thought were signals sent by intelligent beings from another solar system. This brief search for intelligent life beyond our own solar system was the first such experiment of its kind. Eventu-



Life on Other Worlds

by Roy A. Gallant

Of the countless billions of stars in the universe, scientists think that at least 100,000,000 have planets similar to those circling the sun. The fascinating question is "do any other planets in the universe support life?" This photograph shows part of the star field of our own galaxy, plus a distant galaxy (Andromeda) like our own.



More than a hundred years ago, some scientists thought that the moon might be inhabited by "people" like us. We now know that the moon cannot support higher forms of life, but low forms of plant life may exist on the moon.

ally, similar experiments are bound to be performed. What the results will be, no one can even guess right now.

No Men on the Moon . . . or Mars

For centuries men have wondered if there is life—intelligent or lowly forms—in other parts of the universe. At one time the moon and sun were thought to be inhabited by man-like beings (*see drawing*). Earlier in this century one astronomer supposed that an advanced civilization once existed on Mars. What we now know about Mars and the other planets makes it very hard for us to take these ideas seriously; but many years ago, when people knew much less about the planets, such ideas did not seem unreasonable.

In the light of our knowledge today, let's take a quick tour of the solar system and look at each planet as a possible home for man.

Mercury is so close to the sun that the planet's surface rocks heat up to 700°F or more, hot enough to melt lead. No living thing that we know of—plant or animal—can survive in such heat. Also, Mercury has hardly any atmosphere at all; so even if the planet did have a "comfortable" temperature range, the fact that it is an airless world rules out the possibility of man-like Mercurians.

Pluto, the planet farthest from the sun, is equally unfit for any form of life we know about. Because it is so far away from the sun, Pluto is a deep-freeze world. The small planet's surface temperature is thought to be around –400°F day and night.

Venus, like Mercury, seems to be a hot planet. Signals received from Mariner II, as that space probe flew past Venus in 1962, confirmed earlier reports that the surface temperature of Venus seems to be close to 800°F. This, again, is far too hot to support life. But unlike Mercury and Pluto, Venus has a dense atmosphere, with clouds that hide the planet's surface from our view.

Actually, we know very little about Venus's atmosphere. The clouds seem to contain a lot of carbon dioxide, the waste gas that we breathe out. Although carbon dioxide in large amounts is poisonous to animals, plants need it. There is also some water vapor in the atmosphere of Venus, as there is in the earth's atmosphere. What other gases may make up Venus's "air" we do not know. If Venus has high mountains, possibly some forms of life may exist at heights on the mountains where the temperature is lower.

Creatures like us could not possibly live on Mars. Although Mars has an atmosphere, it is much "thinner," or

(Continued on the next page)

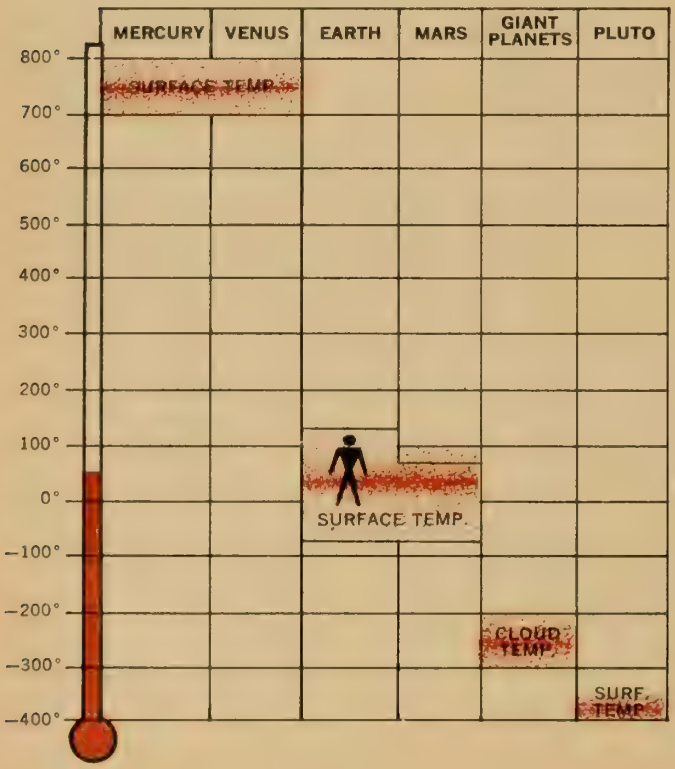
less dense, than the earth's atmosphere. Standing on the surface of Mars would be much the same as being about 20 miles above the earth's surface in our atmosphere: The human body simply could not work. At sea level on the earth, 14.7 pounds of air are pressing on every square inch of your body. At a height of 20 miles—and at the surface of Mars—there would be less than one-half pound of atmosphere pressing on each square inch of your body. In air at such low pressure, you could not breathe. Also, your body fluids would boil away, seeping out through your skin and evaporating.

What little atmosphere Mars has seems to be about 50 per cent carbon dioxide, with some nitrogen and traces of water vapor. Oxygen, the gas that is needed by man and by so many other earth organisms, has not been detected in the atmosphere of Mars.

Water, which is necessary for life, seems to be in very short supply on Mars. Some water is probably frozen in the ground and in thin sheets of frost that form the poles of the planet. No one can yet say for certain whether there are swampy areas on Mars. Mariner IV's excellent photographs of Mars suggest that the surface is as dry and battered as the moon's surface.

At mid-day the temperature at the surface of Mars may be around 70°F, but at night the temperature plunges to at least –70°F. Such harsh conditions on Mars surely must rule out human life, but lower forms of life may exist there. Certain organisms living on the earth have been raised under conditions just as harsh.

TEMPERATURES OF THE PLANETS



"Why, they're just plain folks, like us!"

DRAWING BY LORENZ: ©1965 THE NEW YORKER MAGAZINE, INC.

The Giant Planets

The planets we have not yet mentioned are Jupiter, Saturn, Uranus, and Neptune. These four planets are different from Mercury, Venus, and Mars in many ways. For example, Jupiter, Saturn, Uranus, and Neptune are much larger; their diameters range from four to 11 times the diameter of the earth. Also, their much greater distance from the sun suggests that they are extremely cold worlds—from about –200°F to –300°F. But these temperatures are for the tops of the clouds. What the temperature at the surface of these planets might be, we cannot say.

Another difference is the atmospheres of these planets. They seem to contain mostly hydrogen and helium, with some methane and ammonia. This is hardly an atmosphere that could be used by higher forms of life that we know anything about.

Even so, biologists are extremely interested in these "harsh" atmospheric conditions. At one time in the earth's history, before there was any life on our planet, our own atmosphere might have contained ammonia gas, methane, hydrogen, and water vapor. According to this idea, oxygen, carbon dioxide, and many other gases were added to the atmosphere later in the earth's history. This happened as the earth's surface cooled, releasing many different gases, and after plant life came into being.

Scientists suspect that hydrogen, methane, and ammonia gases are the building blocks of very simple forms of life that developed on the earth. Is it possible, they ask, that life of some sort has developed on Jupiter, Uranus, or Neptune? If we knew the answer, we might have some clues that would help us understand more about how life began on our own planet.

Let's now return to matters closer to home. In our brief survey of the nine planets making up the solar system, we can conclude that people like ourselves could not possibly inhabit any planet except the earth. But what about simpler forms of living things?

Experiments in Martian Biology

If you wanted to find out if certain kinds of earth plants could grow on Mars, what would you do? Since you couldn't bring the plants to Mars, you would have to bring Mars to the plants. In a way, this is what several groups of biologists have tried to do. They have made special containers in which they control the temperature, the kind and amount of air, the length of daylight and night, and other conditions. Into these "Mars chambers" they have put many different kinds of plants—and some animals—to find out what happens to them.

Even though several kinds of organisms seem to thrive in the Mars chambers, biologists cannot say that the organisms would thrive on Mars. There are still too many things we do not know about Mars. For example, we do not know *exactly* what kinds of gases make up its atmosphere, and we know nothing about Martian soil. These two things alone make it very hard to know if the air, temperature, soil, and other conditions in a Mars chamber are anything like the actual conditions on Mars.

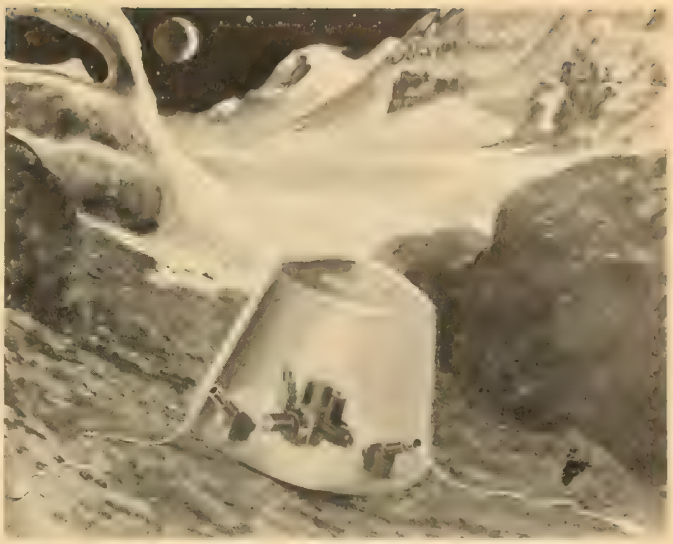
Even so, biologists are learning that many forms of earth organisms are able to live and reproduce in extremely harsh conditions. Dr. D. M. Siegel, of the Union Carbide Research Institute at Tarrytown, New York, is one biologist who is carrying out experiments with a Mars chamber.

So far, he has found that several kinds of seed plants can survive for weeks or months in Mars "air" (*see below*).

MARS (CHAMBER) AIR		**EARTH AIR**	
NITROGEN	97%	NITROGEN	78%
OXYGEN	0.1%	OXYGEN	21%
CARBON DIOXIDE	3.0%	CARBON DIOXIDE	0.03%

Although certain seeds have sprouted and developed into healthy plants, no plant has produced new seeds. For the flower buds to open, a plant must have air that is from 1% to 5% oxygen. But, says Dr. Siegel, "it does not follow that Martian plant life could not have solved this problem."

One of the many interesting things Dr. Siegel has learned from his Mars chamber studies is that certain seed plants and animals (mealworms, for example) can survive at freezing temperatures when there is only a little oxygen in the air. A lot of oxygen in the cold air kills them. Yet, in warm air these organisms need more oxygen; a low oxygen supply in warm air kills them.



This automatic "laboratory" may one day be sent to Mars. Long, sticky strings shoot out, then are reeled in. Any living substances caught on the strings are analyzed, then the information is radioed back to the earth.

Adult insects seemed to get on well in Mars air with from 1% to 5% oxygen. As the air pressure was lowered to 7 pounds per square inch, however, wasps and bees could not fly, or even lift into the air. "If flying life forms are present on Mars," says Dr. Siegel, "they must have very different designs from our own [flying forms]."

Although the Mars chamber experiments carried out by Dr. Siegel and other biologists do not permit us to conclude that life exists on any other planet in the solar system, they make one thing clear. Many kinds of earth organisms can survive in extremely harsh conditions. It seems that the only way we can be *certain* about the existence of life on other planets in the solar system is to send men or space probes to explore them. One such exploration effort is a manned landing on the moon by 1970. Another is to send a biological "laboratory" to Mars (*see drawing*).

What about life elsewhere in the universe, on planets circling very distant stars? Reaching such planets seems impossible today, because they are so far away. If a space probe could travel at the speed of light—which it cannot do —it would take 10 years to make the one-way trip to Tau Ceti or Epsilon Eridani. Radio signals would also take 10 years to reach Tau Ceti—and it would take another 10 years for a reply to reach us.

To reach even more distant stars in our home galaxy would take a space probe or radio signals thousands upon thousands of years. This does not mean that men on earth will never know about life on other worlds. Not too many years ago, reaching the moon was considered impossible; today we are doing it ■

My, What Big Eyes You Have!

■ One evening a few years ago, a college professor was looking at a book of animal photographs while lying in bed. His wife told him that his pupils—the round openings in his eyes—were very large, and that his light must not be very bright. The professor was sure there was enough light; he couldn't figure out why his pupils were so large.

Scientists know that the pupils of the eyes change in size with the brightness of light. When the light is bright, the pupils get smaller, cutting down the amount of light entering the eyes. When the light is dim, the pupils usually get larger. Sometimes fear, surprise, and anger cause the pupils to get larger too.

But the professor suspected that there might be another reason. Could it be his strong interest in the animal pictures? He was especially curious about this because he is a *psychologist*—a scientist who studies the human mind and human behavior.

So the next day the professor—Dr. Eckhard Hess—tried a quick experiment with one of his assistants in his laboratory at the University of Chicago. Dr. Hess gathered up several pictures of country scenes and one picture of a pretty girl. He showed the pictures to the man one at a time. The country scenes had little effect, but when the assistant saw the pretty girl, his pupils got bigger!

Hungry People, Big Pupils

Since then Dr. Hess has watched the pupils of many people in experiments and has made some surprising discoveries. For example, he found that the pupils of a hungry person get bigger when he looks at pictures of food. The pupils change very little when a person who has just eaten looks at food.

To measure the size of pupils, psychologists set up a large box with a screen at one end. Then they flash pictures on the screen while someone looks through the other end of the box. As the person watches the pictures, a camera photographs one of his eyes. Later Dr. Hess measured the diameter of the pupil on the photographs.

Usually Dr. Hess found that a person's pupils get bigger when he looks at pictures of people and things he likes. The pupils get smaller when he looks at someone or something he doesn't like.

Dr. Hess also measured the changes in pupil size as people tried to solve arithmetic problems. A person's pupils start getting bigger as soon as he begins working on a problem. The pupils are largest just as he solves the problem. Then his pupils get smaller again.

What Is Your Friend Thinking?

In other experiments, Dr. Hess watched to see how people's pupils changed size when they tasted food, or listened to music, or looked at pictures of political candidates, babies, sharks, dead soldiers, and many other things. Dr. Hess believes that the pupils tell much about what is going on in the brain. Scientists are now studying changes in the size of pupils to learn more about how people make decisions, and how they change their attitudes. By watching people's pupils as they solve problems, scientists may discover that certain ways of problem-solving are easier than others.

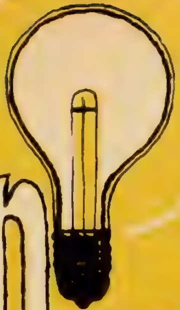
You may never be able to look at the pupils of your friend's eyes and tell what he is thinking. But looking at people's pupils is helping psychologists learn why humans behave as they do ■

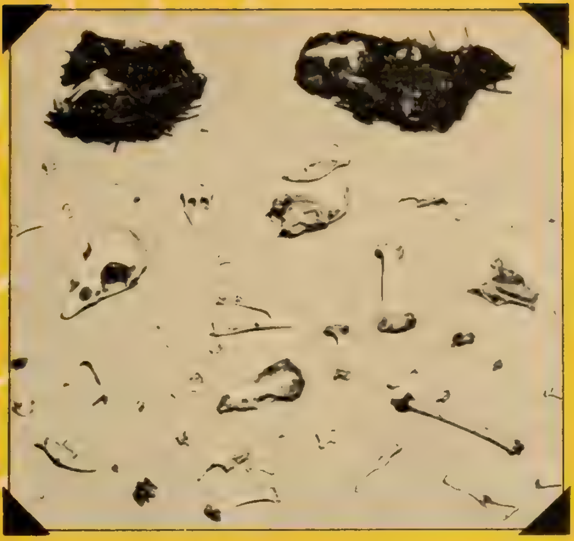
PROJECT

Ask a friend to close his eyes and cover them with his hands for two or three minutes. Then ask him to open one eye. How large is his pupil? Shine a small flashlight (a penlight is best) into his eye. What happens to its size? How quickly does your friend's other pupil change in size in the room light? You can do this experiment yourself, if you wish, by using a mirror.

prepared by
DAVID WEBSTER

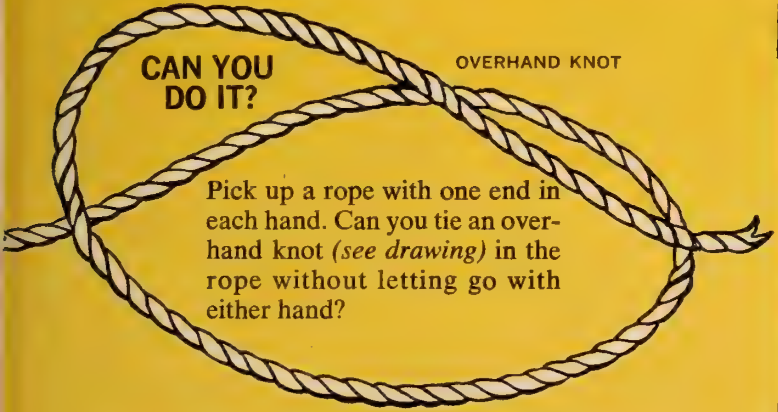
Brain Boosters





Mystery Photo

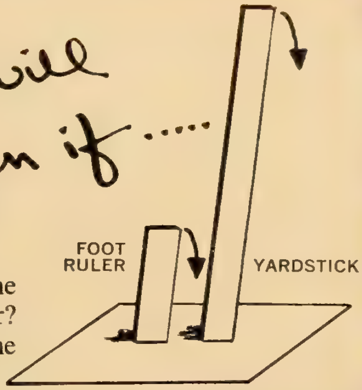
These bones are from several owl pellets (after eating, an owl spits out a pellet an inch or two long that contains the indigestible parts of the animals and birds which it has eaten). What did these owls eat?



CAN YOU DO IT?

Pick up a rope with one end in each hand. Can you tie an overhand knot *(see drawing)* in the rope without letting go with either hand?

What will happen if.....



...the ruler and the yardstick fall over? Which will hit the floor first?

FUN WITH NUMBERS AND SHAPES

Fill in the next three numbers in each sequence:

1 4 7 10 ? ? ?

1 2 2 3 3 3 4 4 ? ? ?

1 3 4 7 11 18 29 ? ? ?

FOR SCIENCE EXPERTS ONLY

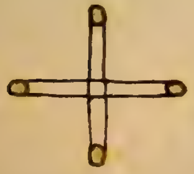
Two balloons are inflated to exactly the same weight and shape with equal amounts of hydrogen. One rises higher than the other. Why? (It is not because of the wind.)

Submitted by David Pagnucco, Detroit, Michigan

● ●

Answers to Brain Boosters appearing in the last issue

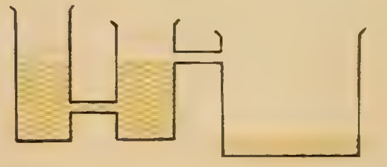
For Science Experts Only: If you breathe out slowly on your hand, your breath will feel hot. This is what you do to warm up your hands in the winter. By blowing hard, your burned finger will be cooled.



Fun with Numbers and Shapes: Here is how to make a square by moving just one match.

Can You Do It? To get the nickel between the two pennies, place your finger firmly on top of the penny in the middle and tap the penny with the nickel. The outside penny should be knocked away so that the nickel can be put in between.

Mystery Photo: The stick which was held in the gas flame is burned in two places. Since the gas needs air to burn, the flame is hottest around the outside.



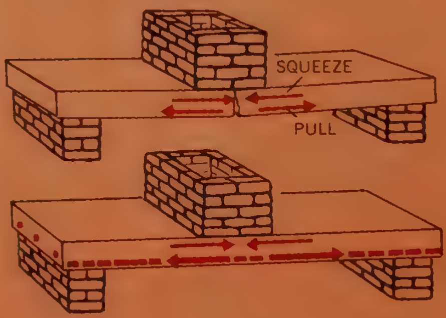
What Would Happen If...? The drawing shows about how the water would be a short time after the valve is opened. Would the same thing happen if oil had been used instead of water?

nature and science | WALL CHART *January 10, 1966*

■ *If you were asked to build a house, how would you do it? Say that you had all the lumber you needed, or metal beams, or blocks of glass, or concrete. You could build any shape structure you chose to build. But the building must be at least 100 feet high. Before you read this chart, try to design a building 100 feet high, using any of the materials mentioned above. After you read the chart, look at your design and see if you think your building would stand up. Can you design a building different from any of the buildings shown on these pages?* ■

REINFORCED CONCRETE

An ordinary concrete slab sags, squeezing the top part of the slab together, and pulling the lower part of the slab apart. If the load is too heavy, the slab breaks in two. Steel rods stretched near the bottom when the concrete is poured reinforce the concrete by taking up most of the pull.



HOW TO

1. A thin shee
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3. You can make
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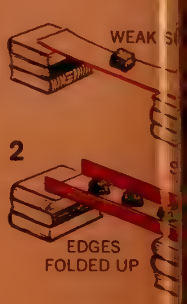
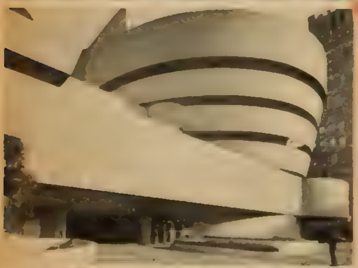
I-beam shape p



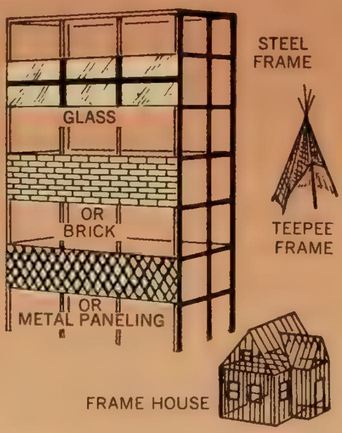
THREE WAYS A BUILDING IS HELD UP

1. A "skeleton," or frame, of steel, wood, or concrete is built. The building can then be closed in with walls of glass, metal, or any other material. (See photo below.) The skeleton, like your own skeleton, supports the weight of the "curtain" walls. 2. Stone or concrete walls hold some buildings up. The taller the building, the thicker the lower walls must be to support the load above. Buildings like this are not more than 15 or so stories high. When they are higher, the ground floor walls have to be so thick (to support the great weight above) that there is hardly any space on the lower floors. 3. When lots of inside space is needed—a museum, for example—a cantilever type building is put up. (See Guggenheim photo below.) Rugged posts support reinforced concrete floors that jut out like balconies.

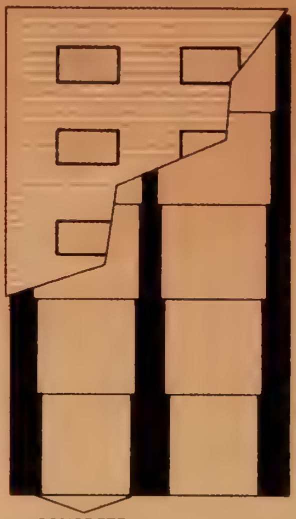


THE SOLOMON R. GUGGENHEIM MUSEUM

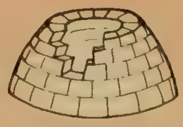
1 CURTAIN WALL BUILDING



2 SUPPORTING WALL BUILDING

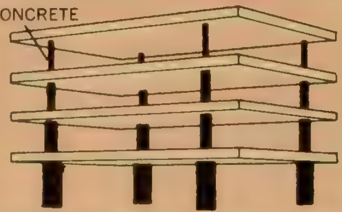


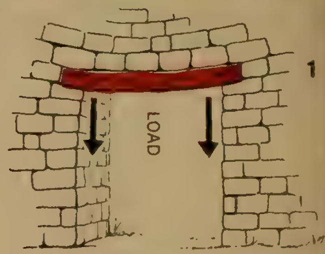
CONCRETE



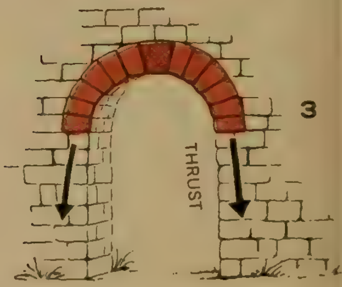
IGLOO

3 CANTILEVER BUILDING

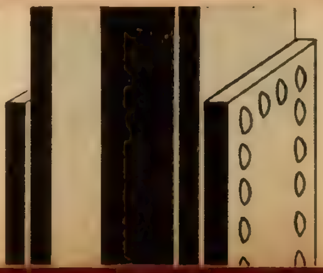




BEAM AND LINTEL ARCH



TRUE ARCH

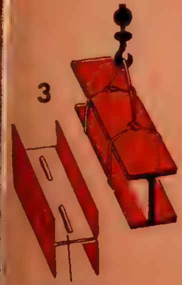


what hold

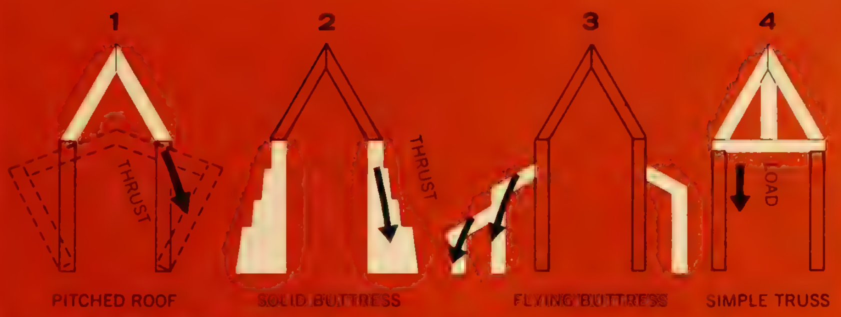
I-BEAM

ırd sags under a edges up gives more strength, a heavier load. m by stapling or ack to back. The l more strength.

3



PITCHED ROOF PROBLEM



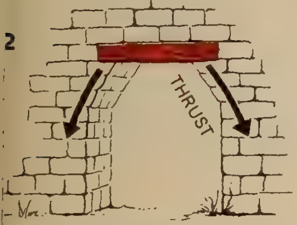
1. The walls of a building with a heavy pitched roof have to support the "pushing-out" force, or thrust, of the roof. 2. Thick, angled walls (solid buttresses) can support the roof load.

3. So can flying buttresses (see photo, at right, of Notre Dame cathedral). 4. The simple truss is another answer to the problem. (Can you figure out why a truss takes up thrust?)

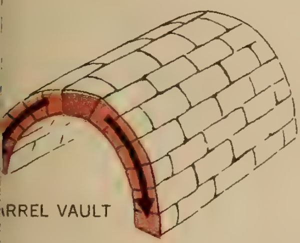
RCH AND HOW IT GREW

can make a beam and lintel bridging two columns with a wood. Too much weight on d will make it break. 2. The l be stronger if you slope the art of the wall inward (a cor- arch). A shorter beam now less load. 3. The true arch is r still. The "keystone," or stone, bears the weight of the pressing in on it. The outward of the top stones is taken up solid buttress structure of the . The barrel vault is simply a f arches.

2



CORBELLED ARCH



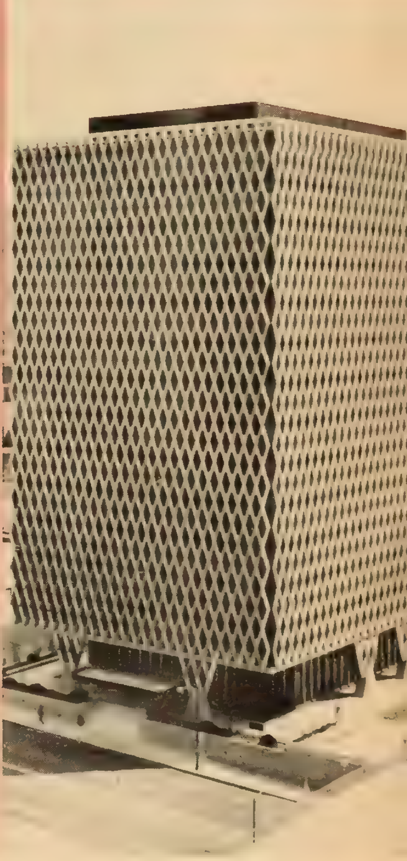
RREL VAULT

NEW SHAPES IN BUILDINGS

New materials and construction techniques enable builders to experiment with new designs and shapes: 1. The gracefully shaped TWA building at Kennedy International Airport in New York has a 6,000-ton reinforced-concrete roof held up by only four buttresses. 2. Pittsburgh's new IBM building has an outside diamond-pattern "skeleton" tha supports the floors (a supporting-wall building) 3. This geodesic dome at the New York World's Fai also has an outside "skeleton," one that serves a both wall and roof frame. The "skin" of the building hangs from the frame.

1

2



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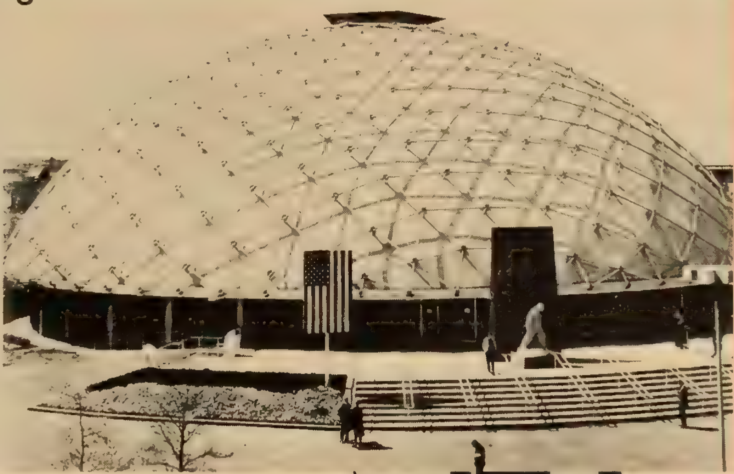
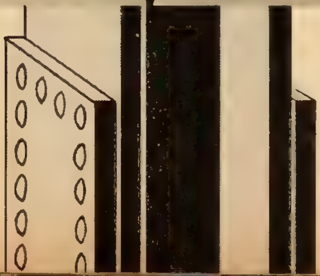


them up?



HOW DOES LIGHT BEND PLANTS?

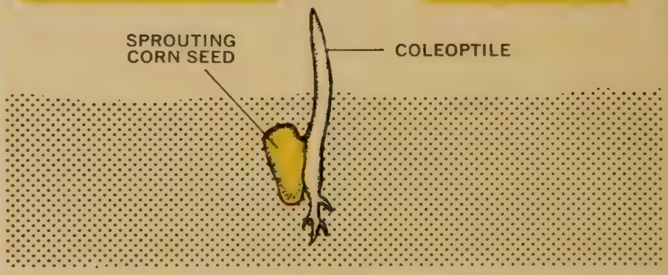
by Richard M. Klein

Scientists are still trying to find out exactly what makes plants grow towards light. Here are some ways you can investigate the effects of colored light on plants.

■ Have you ever noticed that plants growing near windows turn their leaves towards the source of light? Some plants even bend their stems towards light. All this is not new; people had seen it for more than 2,000 years. But it was only when the great scientist Charles Darwin published his book, *The Power of Movement in Plants,* in 1880 that plant scientists *(botanists)* began to take an interest in the movement of plants towards light. This attraction of plants to light is called *phototropism* (photo=light; tropism=movement).

Although Darwin's equipment was simple (he used to raid the kitchen for tools), his experiments were clever and showed a great deal of thought. He decided to experiment with very young seedlings because he could grow them easily in his laboratory and because he could keep them in darkness without using big boxes. Much of his work was done with a kind of grass called canary grass. It sprouts quickly and easily in small pots.

In the grass family, a seedling sprouts with its first leaf covered by a thin sheath, called a *coleoptile (see diagram).* Darwin discovered that this coleoptile sheath is very sensitive to light. In fact, Darwin found that the coleoptile would bend towards light that was so dim that he could not even see it. He also found that the coleoptiles would bend towards a source of light even *after* the light was turned off. Today, 85 years after Darwin studied the coleoptiles of canary grass, botanists are still investigating the bending of coleoptiles towards light.



Dr. Richard M. Klein is Caspary Curator of Plant Physiology at The New York Botanical Garden.

How Plants Bend Towards Light

In recent years, using equipment and ideas which Darwin did not have, we have discovered how the coleoptile

INVEST

Green Plants an

"White" light isn't white. It's red, blue, green, yellow, and all the other colors mixed together *(see "There's More to Color Than Meets the Eye,* N&S, *November 1, 1965).* This fact raises some questions: What colors of light actually cause plants to bend? Does one color, such as blue, cause all of the bending? Or do all the different colors have an equal effect on the plants? Here is a way you can investigate these questions.

First get some corn seed from a garden store. Corn is a member of the grass family, like the canary grass used by Darwin in his studies of plants and light *(see above).* However, corn is easier to get and has a bigger coleoptile than canary grass. Buy corn seed that is all the same brand and variety, because some varieties of seeds have different sprouting times than others. It is important that all the corn seeds sprout at the same time.

You will need about 70 corn seeds for this investigation. *As soon as you buy the corn, plant a few seeds to find out how long it takes for them to grow about two or three inches above the soil.* It usually takes about four or five days. This information will be useful later.

You will also need some sheets of colored cellophane and many other plant parts bend. Here is how it works. The coleoptile is made up of cells. The cells on all sides of the coleoptile are almost exactly the same length. If the cells on one side of the coleoptile (or on one side of a stem) were to become longer than the cells on the other side, this unequal growth would cause the whole cylinder to bend. You can see the same thing by bending a spring *(see diagram).*

The big question in phototropism is: How does light cause cells on only one side of a stem or coleoptile to grow longer? We have several facts which are clues to the answer. Botanists have discovered that the bending toward light won't happen if the tip of the coleoptile is pinched off. This means that the tip is the part of the coleoptile which is sensitive to the light.

But the bending occurs farther down. Darwin studied this by making little caps of gold foil and covering the tips before exposing them to light. He found that the coleoptiles would not bend. He concluded that there must be some "influence" which moves from the light-sensitive tip down the coleoptile and causes bending. More than 50 years later, Dr. Frits Went, working in Java, found that the "influence" suggested by Darwin was a chemical, now called *auxin.* This chemical is formed in the tip of the coleoptile and causes cells to grow longer when it moves down the coleoptile.

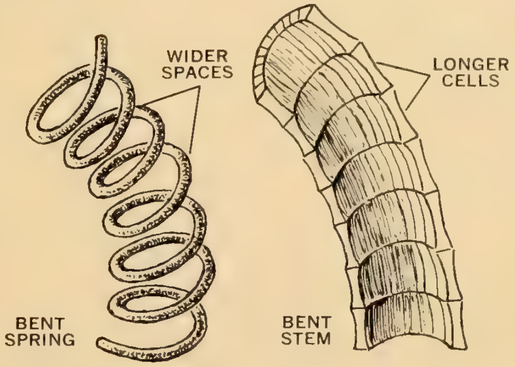
There are still some puzzling questions. How does light cause the auxin to move down the coleoptile? Why does auxin cause only the cells on the side *away* from the light to grow longer? Botanists have some theories that explain these questions, but more experiments must be done to find out which theory is correct. The simple turning of a plant towards light is still not completely understood ■

(The article below tells how you can investigate phototropism, using corn plants.)

ABOUT THE COVER

The photos on the cover show fungus plants bending toward light. The lower left photo shows the tip of a fast-growing fungus. It was photographed every five minutes with a high-speed flash. In all, there are 13 different exposures of the bending plant in the one picture.

The other three photos were taken in the same way, except that the plants were growing on a slow-moving turntable. As the turntable made a complete circle every two hours, the tips of the plants kept turning toward a light that was kept in one place. The pictures taken every four or five minutes show how the fungi kept bending toward the light.



When a spring is bent, the coils on one side are farther apart than those on the other side. A bending plant is like a bending spring. Light causes the cells on one side of a stem to grow longer, so the stem bends toward the light.

GATION

olored Lights

(available from a stationery store). You'll need dark blue, green, amber, and red cellophane.

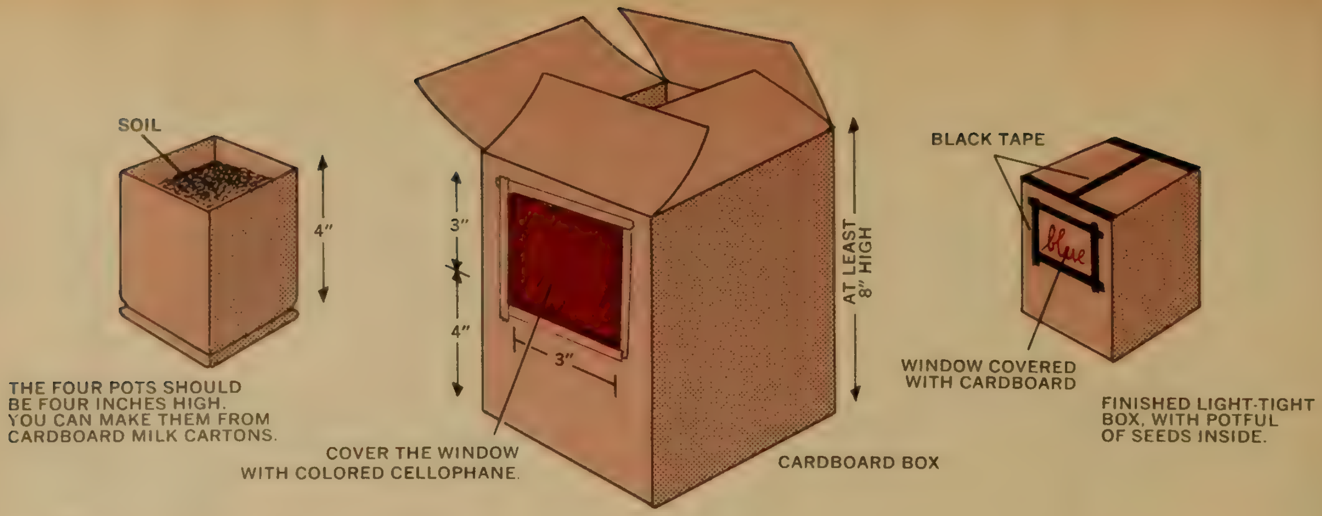
Little Boxes with Windows

In order to control the lighting, you must grow the plants in special light-tight boxes. Make them out of cardboard *(see diagram 1 on next page).* You can make the boxes light-tight by sealing all edges and flaps with black Mystic tape. Make four of these boxes, with a window cut in three of them. Each window should be as wide as the top of the pot in which the corn is to be grown. The window should start at the level of the top of the pot and rise about three inches *(see Diagram 1).* You can then expose the entire coleoptile to light.

Cover the window of one box with two thicknesses of dark blue cellophane. Use one thickness of green and one thickness of dark amber (not yellow) for a second box. Finally, use one thickness each of red and dark amber as a red filter for the third box. Tape the cellophane to the windows with clear sticky tape. Then, using black Mystic tape, put a piece of cardboard over the cellophane win-

(Continued on the next page)

1


SOIL
4″
THE FOUR POTS SHOULD BE FOUR INCHES HIGH. YOU CAN MAKE THEM FROM CARDBOARD MILK CARTONS.
3″
4″
3″
COVER THE WINDOW WITH COLORED CELLOPHANE.
AT LEAST 8″ HIGH
CARDBOARD BOX
BLACK TAPE
blue
WINDOW COVERED WITH CARDBOARD
FINISHED LIGHT-TIGHT BOX, WITH POTFUL OF SEEDS INSIDE.

Green Plants and Colored Lights (continued)

dows so that light cannot enter the box until you want it to. Write the color of the filter on the outside of the cardboard so you can tell one box from another.

Soak about 60 kernels of corn in water overnight. This starts the seeds sprouting. Then plant about 15 kernels in each of the four pots. Make sure that the pointed end of the seed is facing down and that the top of the kernel is about a half inch below the surface of the soil. Put one pot in each box.

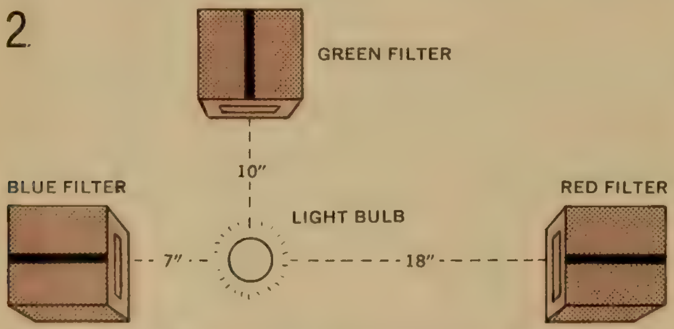
Before sealing the top of the box, make sure that the soil is well-watered. Also, make a mark on the side of the pot that faces the cellophane window. Leave the boxes in a warm room (about 70-75°F) for four or five days (depending on the sprouting time you discovered before).

Now you are ready to expose the young corn plants to light. Use a 100-watt bulb as the light source. Place the lamp so that the bottom of the bulb is level with the bottom of the windows in the boxes.

Some of the cellophane filters let in more light than others. In order to get the same amount of light entering each box, the boxes must be placed at different distances from the lamp. Diagram 2 shows how far each window must be from the center of the lamp.

Next, remove the cardboard covering from the windows and turn on the light. Leave it on overnight. Then take the pots from the boxes. Have all the coleoptiles in every pot bent toward the light? What happened to the coleoptiles that didn't get any light? Compare the amount of bending of the coleoptiles in the different pots. What color of light caused the greatest amount of bending? How far below its tip does the coleoptile bend? What conclusions can you draw from your findings?

2



Set the three boxes at these distances from the light bulb. The bottom of the bulb should be level with the bottom of the window in each of the boxes.

Other Ideas To Test

There are other ways to investigate the movement of plants toward light. You can repeat the above investigation, using stronger or weaker light. Do this by using light bulbs of different wattage, or by moving the lamp. Remember that if you double the distance between the lamp and the box, you will get one-fourth as much light. Tripling the distance will give you one-ninth as much light. But if you halve the distance you will get four times as much light.

You will also investigate the effects of lighting one side of the coleoptiles with strong light and the other side with weaker light. Or light one side with one color and the other side with another color. What happens?

You can also try some investigations with the tips of coleoptiles, as Charles Darwin did. Grow two potfuls of corn seeds in separate light-tight boxes. The boxes should have windows, but do not cover the windows with colored cellophane. Plant the seeds, seal the boxes, and cover the windows with cardboard as you did before.

After three days, open one box and snip off the tips of the coleoptiles. Do this in the dimmest light possible. Or cover the tips with caps made of aluminum foil. Then close the box and allow 24 hours before exposing the plants in both boxes to light. After leaving the light on overnight, look at the coleoptiles in both boxes. Compare them. What can you conclude from your observations?

What do you suppose would happen if you slipped a length of transparent plastic straw over a coleoptile to keep it from bending toward light?

Who ever heard of a... WHITE CROW?

■ For centuries, white animals have caught the imagination and curiosity of man. The American Plains Indians, for example, considered a white bison (buffalo) a sacred animal. When they killed one, they would preserve its hide and hang the hide above all other offerings at their ceremonies. Only a medicine man could use such a hide.

Where did these sacred white bison come from? As any viewer of western movies will tell you, bison are usually dark brown in color. The rare sacred bison were *albinos*—all-white animals with pink eyes. Albinos appear in many groups of animals. For example, there are albino fish, monkeys, snakes, raccoons, and crows. (The photo on this page shows an albino raven, a close relative of the crow.) About one out of 20,000 humans is an albino.

How Albinos Happen

The color of an animal's skin, fur, or feathers is passed on, or *inherited,* from its parents. Usually, a young animal inherits the same color of fur or feathers that its parents have. Young crows, for example, are almost always black like their parents. Sometimes, however, there is a change in the egg of the female crow or in the sperm of the male. After the egg and sperm unite, the unborn crow inside the egg develops in an unusual way. When the young crow hatches, its body cannot make a dark brown or black coloring substance (*pigment*) called *melanin,* that is in the feathers of other crows. This is one way in which an albino crow may come about. (Melanin in human skin usually increases in the sunlight. This is why you tan or freckle when you spend a lot of time in the sun.)

An albino can also come about because something goes wrong with the cells that produce substances needed to form melanin. This happens most often during an animal's early life.

Albinos are usually completely white, except for their pink eyes. The eye color comes from tiny blood vessels in the eye that are usually masked by pigment. With the pigment missing, the eye is especially sensitive to bright light. You may have seen human albinos wearing dark glasses outdoors and special glasses indoors. The skin of human albinos is also very sensitive to light; they sunburn easily.

Not all albinos have white fur, feathers, or skin. Even if an animal has no dark melanin pigment, it may have other colors. Also, an animal may have dark pigment missing from just part of its body. Or it may have a "washed-out" look, with less melanin than usual spread over its body.

Other animals, called *melanistic,* have *more* dark pigment than usual. Black squirrels, for instance, are really gray squirrels with extra melanin in their fur.

Why Albinos Disappear

If two albinos mate, all of the young will be albinos. By breeding animals in this way, men have produced great numbers of albinos, including rabbits and mice which you have probably seen.

Albinos living in the wild are rare though. They have two strikes against them—poor eyesight and a color that makes them stand out from others of their kind. They are easily spotted by their enemies and usually don't live long enough to have young. —Rod Cochran

A Puzzler

This article tells about albino animals, but there are also albino plants, including corn plants. They die just a few days after sprouting from seeds. Can you explain why?

Case of the vanishing SALT

Can you find the "solution"?

■ PROBLEM: If you had a pound of salt and a pound of sand all mixed together, what would be the easiest way to separate the salt from the sand?

Look at some grains of salt and grains of sand through a magnifying lens. Are they different enough in color, shape, or size so that you could pick them apart with some pointed tweezers? Perhaps you could separate some of the grains, but what a job it would be!

If you poured the mixture into a large jar, covered the jar, and shook it for a while, maybe the heavier grains of sand would drop to the bottom of the jar. You can find out if this would work by mixing half a teaspoon each of salt and sand and pouring the mixture into a small pill bottle. Cover the bottle and shake it back and forth, keeping the bottom end downward. Do you think you could separate *all* of the sand and salt this way? Do you suppose that you could change the grains of salt in some way to make them easier to sort out?

Try This Solution

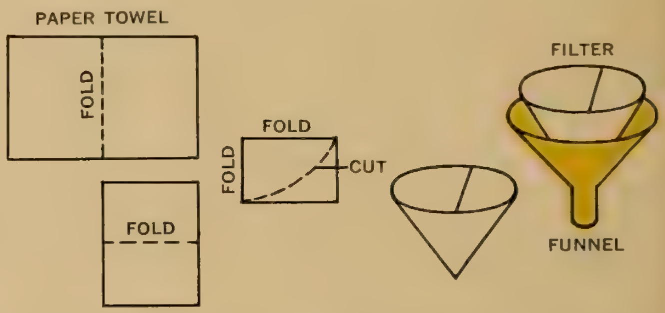
Pour some warm water into the mixture. Cover the bottle and shake it for about half a minute. Can you see the salt grains now? What do you think happened to them? What is left in the jar?

The tiniest particles of a substance like salt are called *molecules*. Salt molecules are too tiny to be seen, but a lot of salt molecules sticking together form a grain, or *crystal*, of salt, which you *can* see. The smallest particles of water are molecules, too. Water molecules have a strong attraction for the tiny particles that make up a salt molecule. When you put salt in water, the water molecules pull apart the tiny particles making up the salt molecules. Scientists say that the salt has *dissolved* in the water, forming a salt-water *solution*.

But why doesn't the sand dissolve in the water? Sand grains are made of molecules, too, but they are different from salt molecules. The tiny particles making up a sand molecule attract each other so strongly that water cannot pull them apart.

Suppose now that you had a special strainer, or *filter*, with holes small enough to stop the sand grains, but let the salt-water solution pass through. Would it trap the salt molecules when we pour the solution through? You can make a filter like this by folding a sheet of paper towel and putting it into a kitchen funnel *(see diagram)*. Or you can buy filter paper with even smaller holes (the kind used in a filter coffee maker) at a grocery or drug store.

Hold the funnel with its spout in a glass and pour the mixture of sand and salt-water solution into it. If you use a paper towel filter, some tiny grains of sand may go through the filter with the solution. Try filtering the solution several times. Use a clean filter paper each time. Let the filter papers dry, then carefully shake the sand off them onto a sheet of paper. Did you recover the same amount of sand that you mixed into the salt?



To make a filter, fold a sheet of paper towel twice, then cut off the unfolded corner, as shown above. Open the paper to form a cone and place it in the kitchen funnel.

Now the problem is to recover the salt or get it out of solution. To do this, let the liquid stand in a warm place until the water has all *evaporated*, or changed to water vapor and floated off into the air. You can hurry this process by pouring the solution into a metal pan and heating it gently. When the water is all gone, how much salt is left in the pan?

When Is a Mixture a Solution?

If you can separate substances that are mixed together by picking them apart, or by letting the heavier substance settle to the bottom of the container, or by filtering, the mixture is called a *mechanical mixture*. A *solution* is a special kind of mixture. To separate two substances that

Does this substance... form a solution (S) or a mechanical mixture (M) with these substances?

	WATER	MILK	SALAD OIL	LIQUID DETERGENT	RUBBING ALCOHOL	CLEANING FLUID
SALT	S					
FLOUR						
SUGAR						
BAKING SODA						
CHOCOLATE						
SOAP						
BREAD						
GRAVY						
BUTTER						
SALAD OIL						
RUBBING ALCOHOL						
LIQUID DETERGENT						

make up a solution, you have to change the form of one of them—by changing the liquid into a gas (by evaporation) or into a solid (by freezing).

How many substances can you find that will dissolve in water? Try such things as flour, baking soda, a piece of chocolate, soap, bread, gravy. You can probably think of many more things to test. Keep a record of your tests on a chart like the one on this page.

Begin with a container of water at room temperature, and measure out the same amount of water for each test. Pour the water into a small glass or jar, then measure out half a teaspoon of flour (or whatever you are testing) and drop it into the water.

If the flour does not seem to be dissolving, stir it. Try setting the glass in a pan of hot water and keep stirring. some substances dissolve slowly; heat makes them dissolve faster by speeding up the molecules of both the flour and the water. If you think the flour has dissolved in the water, test it by filtering. If all of a mixture passes through the filter paper, see if you can recover the substance by letting the water evaporate.

Will the substances that you tested in water dissolve in other liquids? Try them in milk, salad oil, liquid detergent, and rubbing alcohol, for example. Which liquid is the "best dissolver" of different substances? Do some substances that won't dissolve in water dissolve in other liquids? (Try dissolving a very small amount of butter in a spoonful of water, then in a spoonful of cleaning fluid, such as Carbona or Renuzit.)

You might also try mixing another liquid, such as salad oil or ink, with water. Shake them up in a jar, then put the jar down and watch what happens—when you let it stand awhile. Does the same thing happen to the ink and water that happens to the oil and water?

You Can't Escape from Solutions

Most of the liquids on earth are solutions. The water in the oceans, lakes, and streams has some minerals and usually some gases (air) dissolved in it. The only water that does not have something dissolved in it is *distilled water*. This is water that has been changed to water vapor to separate it from other substances. Then the water vapor is cooled so that it changes back into liquid water. Even rain water often has substances from the air mixed or dissolved in it. Try filtering and evaporating some rain water to see how pure it is.

There are solutions inside of you, too. Most of the food that you eat dissolves in the digestive juices in your stomach. Once in solution, the food molecules pass into your blood stream and are carried to all parts of your body to supply energy and building material. Your blood and other body fluids are all solutions of salt and other substances in water—and your body is two-thirds water ■

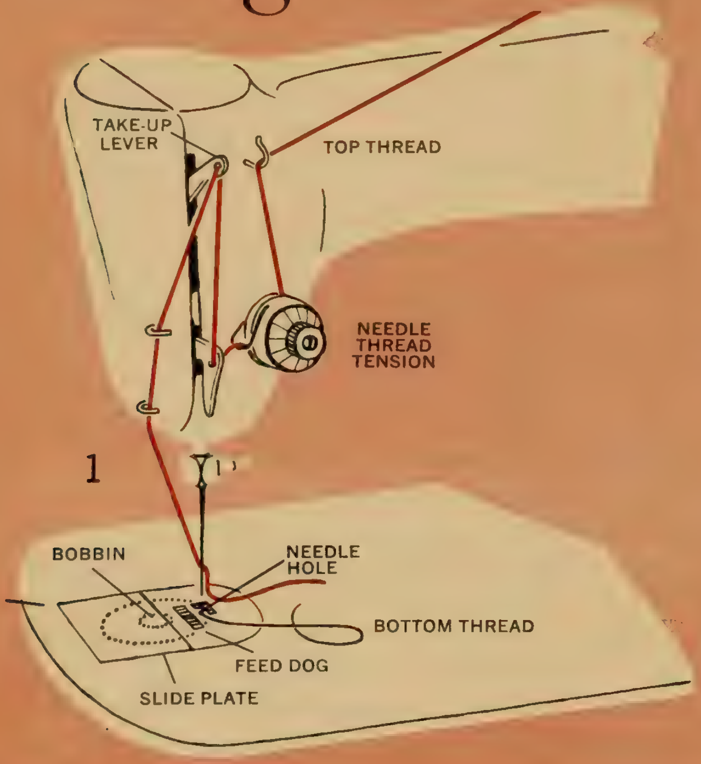
INVESTIGATION

A solution that contains only a little bit of dissolved material is called a *dilute solution*. The more material you dissolve in a solution, the more *concentrated* it becomes. When you can't dissolve any more material in the solution, it is said to be *saturated*. How much sugar can you dissolve in half a cup of water before it becomes saturated?

You can find out by slowly dropping sugar into the water as you stir it. Use a measuring spoon, so you can keep track of how much sugar you pour in, and stop pouring as soon as you see grains of sugar that are not dissolving. The solution is then saturated. Set the glass in a pan of hot water, or pour the solution into a small pan and heat it gently on the stove. Now can you dissolve any more sugar in the water? When the solution is saturated again, cool the glass or pan in the air or in some cold water and see what happens. Do you think that heating a solution will always allow you to dissolve more of a substance in it? Try the same experiment with salt and other substances.

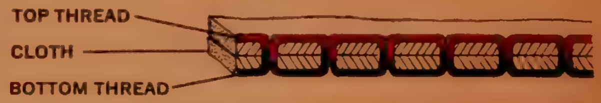
HOW IT WORKS

sewing machine



1

■ Sewing by hand is a slow process. It takes even longer if you want to make *lockstitches,* like this:



A sewing machine can make as many as 2,200 lockstitches a minute! Here is how it works.

The *top thread* (brown) comes from a spool on top of the machine. It runs through the *needle thread tension* (which keeps the thread at the proper tightness), then through the *take-up lever,* and down through the eye of the needle, which is near the point *(see Diagram 1).*

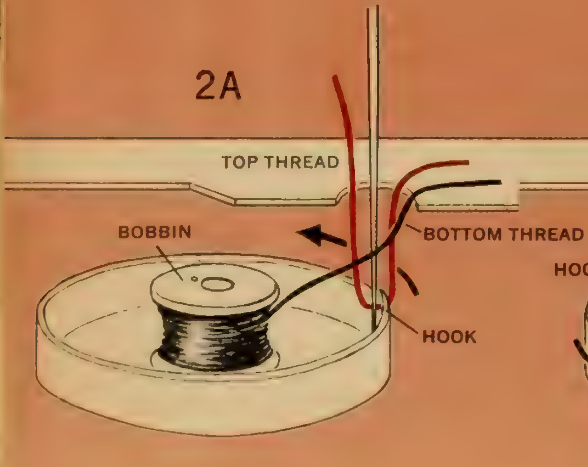
The *bottom thread* (black) comes from a small spool called the *bobbin,* which rests in the *bobbin case* under the *slide plate.* How do the two threads get together to make a lockstitch?

First, the threaded needle goes down through the cloth and into the needle hole. When the needle reaches its lowest point in the hole, the brown thread is caught by the *hook* in a collar that turns around the bobbin case *(see Diagram 2A).* As the collar turns, it pulls a loop of the brown thread over and under the bobbin case *(see Diagram 2B).* When the hook nears the needle hole again, the brown thread is pulled upward by the take-up lever. This lifts the brown thread out of the hook and tightens the loop it has just made around the black thread, forming a single lockstitch *(see Diagram 2C).*

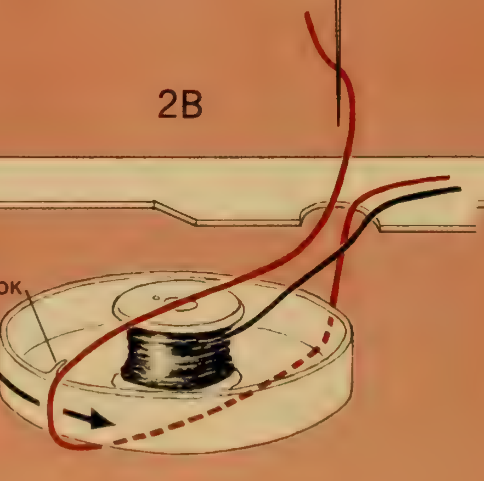
By this time, the needle has lifted out of the cloth, and the *feed dog (see Diagram 1)* has pushed the cloth a short distance so it is ready for the next stitch.

An electric motor inside the sewing machine moves the needle and take-up lever up and down, turns the hook collar, and moves the feed dog back and forth. The motor is switched on and off with a foot pedal or a lever operated by the sewer's knee ■

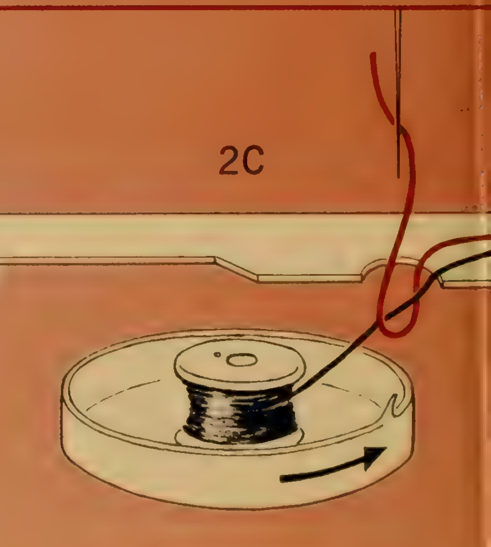
2A



2B



2C



Using This Issue...
(continued from page 2T)

cells to form dark brown or black pigment. By definition then, an albino is not always white; other pigments may be present. Although it is sometimes caused genetically, it may also be caused by chemical changes in the pigment-forming cells.

Genetically, albinism comes about through a *mutation*—a change in the gene or genes that control the production of melanin. But albinism is a *recessive* character, so the results of this mutation may not show up for several generations. When a normally colored individual and an albino mate, all of the offspring will have normal color, since each young animal has inherited a gene for normal color (a dominant character) and a gene for albinism (recessive).

If two of these offspring are mated, about a quarter of their young will be albinos, the rest normal. For *all* of the offspring of any mating to be albinos, both parents must have only recessive genes that produce albinism (they must be albinos themselves).

Most mutations are harmful. Some result in the early death of an organism, often before its birth. The albino corn mentioned in the "puzzler" at the bottom of page 13 is an example of a lethal mutation. The missing green pigment is *chlorophyll*, a vital ingredient in the food-making process of photosynthesis. Albino corn seedlings grow for a time using stored food in the seed.

Activity

Botanists have managed to keep albino corn plants alive by dipping the tips of their leaves in a solution of sugar and water. They cut off the tip of one leaf (about 10 days after planting), and keep it dipped in a two per cent sugar solution. The sugar solution must be changed daily and fresh cuts must be made to insure the flow of food into the plant.

You might divide your class into teams and have an "albino plant race," with a prize for the group that is able to keep their plant, or plants, alive the longest. You can buy albino corn seeds from the biological supply houses listed on this page.

14 Vanishing Salt

After your pupils have made the investigations proposed in this article, you might ask them some questions that will expand and reinforce their understanding of solutions and mechanical mixtures.

Topics for Class Discussion

- *Does it matter how much of each different substance you use to make a mechanical mixture or a solution?* Not for a mechanical mixture, but there is a limit to the amount of one substance that can be dissolved in another substance *(see Investigation, page 15).*
- *Are substances distributed evenly throughout a mechanical mixture? A solution?* Some substances (e.g., sand and salt) can be mixed together so that they are fairly evenly distributed, but this is not a requirement for a mechanical mixture. The substances making up a solution, however, are evenly distributed. All parts of the solution are the same in composition and structure, making it *homogeneous.* (Ask your pupils why milk is "homogenized".)
- *Can gases be dissolved in other substances?* Yes. For example, water usually has some air dissolved in it. (The bubbles in ice cubes are formed by air that comes out of solution when the water is changed to solid form.) Ask your pupils if they think there is any gas dissolved in soda pop. It contains carbon dioxide under pressure, some of which is in solution, the remainder an invisible gas in the top of the bottle. Without shaking the bottle, remove the cap. Your pupils can see bubbles rising out of the solution as the gas evaporates, or boils off, into the air.
- *Are there any solid solutions?* Yes. For example, molten copper and silver form a liquid solution and harden into a solid solution called sterling silver. However, many other alloys are non-homogeneous mixtures of metals.
- *Why are solutions so important in our lives?* As described in the article, the energy and building materials for our bodies comes from food that is dissolved in our body fluids and carried in solution to the point of use. Equally important is the fact that the processes by which food is converted to energy and living cells can only take place when the substances are in solution.

Many substances that *do not* combine to form new substances (compounds) when simply mixed together *do* form new substances when they are dissolved together in a liquid such as water. You can demonstrate this by mixing some calcium chloride (from drugstore) and sodium carbonate (baking soda) together on a piece of paper. Nothing happens. But if you dissolve the mixture in water, the molecules of the two compounds come apart. The atoms of sodium combine with the atoms of chlorine to form sodium chloride (salt) and the atoms of calcium combine with those of carbon to form calcium carbonate (chalk).

Chalk is not soluble in water, so it settles to the bottom of the container. Filter the chalk out of the solution, then evaporate the water and the substance left is salt.

Biological Supply Houses

- Ward's Natural Science Establishment, Inc., P.O. Box 1712, Rochester, N.Y. 14603.
- Ward's of California, P.O. Box 1749, Monterey, Calif. 93942.
- General Biological Supply House, Inc., 8200 S. Hoyne Ave., Chicago, Ill. 60620.
- Carolina Biological Supply Co., Burlington, N.C.
- Powell Laboratory Supply Co., Gladstone, Ore.

Activities

- Have your pupils make a list of as many different solutions as they can think of. If there is any question as to whether something is a mixture or a solution, have someone test it as suggested in the article. If this is impossible, or likely to be dangerous, have someone try to find out from a reference source.
- Have your pupils think of as many kinds of filters as they can. For example, window screens, kitchen strainers, vacuum cleaner bags, etc.

CORRECTION

In the November 1, 1965 issue of *Nature and Science*, an error appeared on page 9 of the student's edition and on page 2T of the Teacher's Edition. In both places, the pika is referred to as a rodent. Although pikas resemble some rodents in appearance and habits, they are classified in the order Lagomorpha. The lagomorphs include rabbits and hares, and have four incisor teeth in their upper jaws while rodents have just two.

Can You Disappear?

(Continued from page 1T)

action of objects. Some commercial firms are already offering such materials.

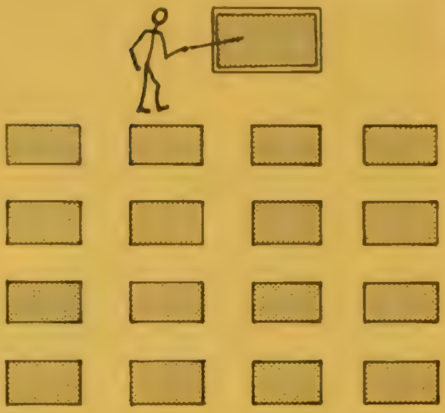
Many of the experiments for which science textbooks give precise directions in cook-book fashion can be set before the children with only this directive: "See what you can find out."

Results That You Can See and Hear

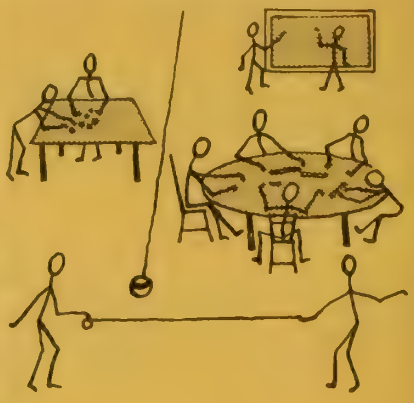
How do we know that any learning takes place while children engage in free, undirected experimentation? Maybe it's just play? Apart from the fact that play is the young child's—and for that matter all young animals'—way of learning, if the materials are suitably selected we can observe and hear the learning that takes place. We can check it in the faces, actions and sometimes the words of every child.

A 10-year-old boy who had been experimenting freely with dry cells, wires and light bulbs said, "I discovered something I couldn't think of [*meaning serendipity!*]—that two small batteries could light the bulb brighter . . . two bulbs brighter . . . than the big battery and the medium battery." An 11-year-old who was having his first experiences with this same set of materials mused, "I wonder if I'll get shocked by putting this wire in my mouth?" He made a grimace, placed the wire in his mouth and his grimace was transformed into a knowing grin.

Did the classroom you sketched look like this?...



Or did it look more like this?



Another 10-year-old boy was having his first experience with free experimentation—this time with magnets. He hung one magnet on a string and made it dance by moving another magnet near it. He then discovered that he could make a small cylindrical alnico magnet spin around in an "about face." He called his friends to witness the phenomenon but failed, at first, to repeat the discovery. Then he turned the magnet he was holding so that the other pole faced the magnet on the table. It worked.

An immature seven-year-old had been pouring water through various strainers and funnels from one vessel into others. She suddenly tried pouring water through a paper towel which was on the table for quite another purpose! She said that the towel must have little holes in it to allow the water through. She held a fresh piece of towel up to the light to confirm her hypothesis.

Discovery, Communication, Curiosity

There is great doubt that the children would have learned these things with a teacher up front directing observations. It is even doubtful whether a teacher would have led children to just these discoveries. Yet these facts coming from personal involvement not only become a part of the discoverer's knowledge; they also motivate a need to tell others, to communicate ideas, to develop a language adequate for expressing the excitement. Such experiences keep alive the childish (and scientific) desire to learn more about the world that surrounds us all.

Can you conceive of a classroom with children in groups working with thought-provoking materials while the teacher circulates, watching faces and listening to spontaneous and pointed remarks? It's worth a try, for the dividends are great ■

(Articles in N&S *about different methods of teaching science do not imply endorsement of any particular method by The American Museum of Natural History.)*

nature and science
EXPLORING PREHISTORIC LIFE
The Duck Billed Dinosaur Puzzle see page 10

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nature and science
TEACHER'S EDITION

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Cuddly Animals and Talking Atoms

by Thomas G. Aylesworth

■ "During that long, long time, each animal's appearance changes because each animal has developed its own way to meet the changing seasons."

That's a quote from a book manuscript intended for young readers in the fifth and sixth grades. Now, you know what the author meant and I know what the author meant, but will your pupils know what the author meant?

Doesn't the quotation sound a little bit as if each individual animal intellectually decided to develop its own way to meet the changing seasons? The snowshoe rabbit looks up at the sky one day and says, "Oh boy, it's time to turn white." The tree feels a chill in the air and says, "Time to drop my leaves."

Personification

Thousands of words have been written, scores of studies have been made, descriptive statements have been published by scientists and educators, all to the effect that it is improper to let personification creep into the classroom. Yet, at times, it not only creeps in, it dominates instruction.

The habit of personification is a hard one to break, however. The reason for this is probably that it is so hard to detect. Our daily lives are filled with cartoon animals, singing chipmunks, and talking automobiles on television; nature study books depicting a sentimental world of cuddly animals; and even science charts in magazines showing chemical atoms with smiling faces charging around inside beakers filled with clear liquids.

At best, such things give rise to confusion on the part of youngsters and oldsters alike. At worst, they make it impossible for us to understand the broad aspects of science. Personification is a formidable problem, also, because it comes in three different disguises.

Animism

The first type of personification is called animism. This is the practice of attributing life or living characters to non-living things.

We've all heard many statements such as, "The balloon exploded because the air was trying to escape," or, when describing tides, "As the earth spins on its axis, it tries to carry both water bulges with it."

Of course, we could argue that nobody really takes these statements literally. We could dodge behind the old excuse, "But you know what I mean."

But even if the reader does know what the author means, there is a danger that the reader's attention will be diverted from an understanding of the basic laws of the physical sciences. The reason for this is that it is much easier to depend on a hazy, ill-defined notion that the earth "wants" to hold onto its water bulges, than it is to develop a concept concerning the forces involved in astronomical mechanics.

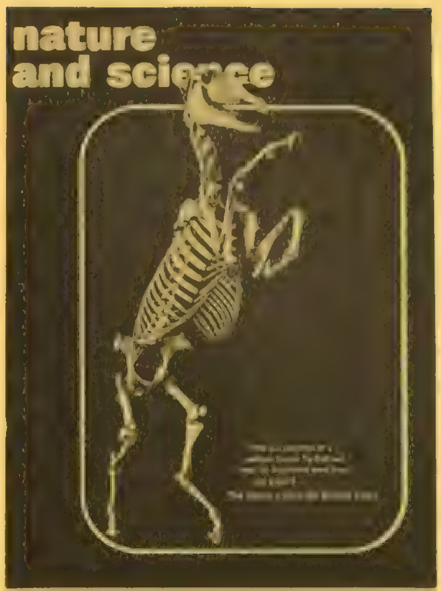
Anthropomorphism

A more common type of personification is anthropomorphism. In this type, human characteristics are attributed to nonhuman beings. It is probably the most popular. For example, the opening quotation in this article was one of anthropomorphism.

We find it in films—even in some films that are stoutly defended by biology teachers. But what kind of an impression do these films give when they speak of a hungry bear who has found a salmon to eat as "The Prince of Darkness," or describe a mountain

(Continued on page 3T)

Dr. Thomas G. Aylesworth is a member of our National Board of Editors.



IN THIS ISSUE

(For classroom use of articles preceded by ●, see pages 2T and 3T.)

Moving Things with Electricity
Your pupils can make a simple solenoid and automatic circuit-breaker that demonstrates the basis for motion in an electric motor.

● Around the World with Captain Cook
Part I of this two-part series tells of the famous explorer's voyage into the Pacific to participate in a project for measuring the distance from the earth to the sun.

Reflections—How To Turn Them Off
By experimenting with Polaroid sun glasses, your pupils can find out how light waves of different polarity can be separated.

● The Horse's First 55 Million Years
The highlights of horse evolution, traced from the terrier-sized eohippus to the modern horse.

● Boxes for Birds
How your pupils can help bolster local bird numbers by putting up bird houses.

Seeing More with Your Microscope
Further investigations your pupils can make with a simple microscope.

IN THE NEXT ISSUE

Captain Cook's search for the Great Southern Continent . . . How scientists use photography . . . The magic of moiré patterns . . . A SCIENCE WORKSHOP on molds and garbage . . . The pine marten: symbol of wilderness . . . Brain-Booster contest.

USING THIS ISSUE OF NATURE AND SCIENCE IN YOUR CLASSROOM

PAGE 4 Captain Cook

Part 1 of this two-part article about James Cook's 1768-71 voyage to the South Pacific deals with the expedition's observation of the 1769 transit of Venus. (Part 2, in the next issue, will deal with Cook's exploration of New Zealand and the eastern coast of Australia.)

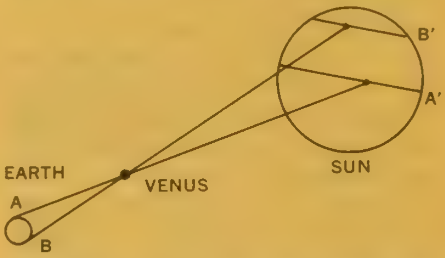
Suggestions for Classroom Use

Your pupils may have read about the International Geophysical Year, in which scientists in many countries cooperated in planning and carrying out investigations of the earth and in exchanging information and conclusions based on their findings. The project to measure the distance from the earth to the sun during the 1769 transit of Venus across the sun was an early example of such international cooperation among scientists.

Your pupils probably can give the mean distance between the earth and sun as 93,000,000 miles. This distance is called the *astronomical unit,* or a.u., and is used in measuring distances within the Solar System. However, they may be surprised to learn that the size of the astronomical unit in miles (the most recent figure is 92,956,000) may be in error by several thousands of miles.

In the early 1700s, measurement of the a.u. in miles was about 75 per cent as accurate as today's figure. The relative distances of bodies in the Solar System were known, but not their absolute distances in miles.

The project in which Cook participated had been suggested by the British astronomer Edward Halley, who died in 1742. When Venus was in a direct line with the earth and the sun, the distance from the earth to Venus would be about three-tenths of the distance from the earth to the sun (0.3 a.u.). Observers at widely separated points on the earth would see Venus crossing the sun's disc along different paths *(see diagram).* If Venus's transit along each of the observed paths could be accurately timed, it would be possible to figure out the diameter of the sun and its distance in miles from the earth.



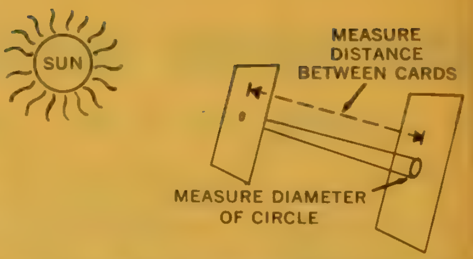
An observer at A on the earth would see Venus cross the sun's disc along path A' during transit. An observer at B would see the planet cross at B'.

As the article notes, the "black-drop" effect *(see Activities)* prevented any of the observers from timing the transit very accurately. As a result, the earth-sun distance was open to large error. Nevertheless, Encke's figure of 95,300,000 miles was used for about 30 years. A lesson to be drawn from this is that scientists often know that their data is "fuzzy," yet it may be the best they have to work with at the time.

Activities

- With your help, your pupils might enjoy setting up a proportion of their own and calculating the sun's diameter (which is 864,000 miles). Here is how to go about it. Punch a small hole in a piece of cardboard and let the sun shine through the hole and form a circle of light on another piece of cardboard held parallel to the piece with the hole *(see diagram).* The cardboard with the hole in it should be held perpendicular to the sun's light. By measuring the diameter of the circle of light, you can then set up a simple proportion:

$$\frac{\text{Diameter of Sun (mi.)}}{\text{Diameter of circle of light (in.)}} = \frac{\text{Distance to sun (mi.)}}{\text{Distance to circle from hole (in.)}}$$



Your pupils can calculate the sun's diameter with two pieces of cardboard and a simple proportion.

Warn your pupils never to look directly at the sun; permanent damage may be done to their eyes.

- Your pupils can see the "black-drop" effect that prevented accurate timing of the Venus transit. Have them look at a light (*not* the sun!) and bring the tips of their index fingers almost—but not quite—together about six inches in front of their eyes. They should see a little black "bridge" jump between their fingertips just before they touch each other.

Navigation at Sea

During Cook's voyages, finding latitude at sea did not pose a problem. Cook had a good sextant with him. With a sextant all you have to do is measure the distance, in degrees, of the North Star (if you are in the Northern Hemisphere) above the horizon. If its *altitude* is 20°, then your latitude is 20°N. Navigators of Cook's time, and before, therefore, usually sailed directly to the latitude of their destination. They then kept to that latitude as well as they could and sailed dead east or west toward the coast, knowing that if they kept their latitude they would eventually reach their destination. Determining longitude was more difficult.

Accurate determination of longitude depends on accurate timekeeping. Although Cook had an accurate chronometer with him on his later voyages, he did not have one during his 1768 voyage. Difference of longitude is really the difference between local

(Continued on page 3T)

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nature and science

VOL. 3 NO. 9 / JANUARY 24, 1966

His orders were to observe Venus making a rare crossing of the sun, then to search for a continent that wasn't there.

see page 4

AROUND THE WORLD WITH CAPTAIN COOK

This is a skeleton of a
modern horse. To find out
what its ancestors were like,
see page 8...

The Horse's First 55 Million Years

nature and science VOL. 3 NO. 9 / JANUARY 24, 1966

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SCIENCE WORKSHOP

moving things

With some wire, wood, tacks, and a flashlight battery, you can make electricity move a nail—and keep it moving.

■ Electricity is used to do many jobs around your house, such as lighting a room, toasting bread, washing clothes, and maybe even brushing your teeth. You may be surprised to find out that electricity works in only two different ways to do all of these different jobs.

One way is by *heating* something. In an electric toaster or light bulb, for example, the electric current flows through wires that tend to hold back the current. As the current pushes through the wire, it makes the atoms and molecules of metal that make up the wire move around faster than they do when there is no current going through the wire. This produces heat *(see "Exploring Heat and Cold—Part 3,"* N&S, *December 6, 1965)* which will toast bread, for example. In a light bulb, the wire gets so hot it gives off white light.

The other way that electricity helps do jobs around your house is by *moving* something. Machines such as washers, vacuum sweepers, fans, refrigerators, and so on, have moving parts. These parts are kept moving—usually turning—by an electric motor. A current of electricity flowing through the motor turns a metal bar, or *shaft,* which is connected to the other moving parts of the machine. How does electricity move things?

Making Magnets with Electricity

One way to make a magnet is by sending an electric current through a wire. A magnet like this is too weak to pull a nail to the wire. If you increase the amount of electricity flowing through the wire, it will have a little more magnetic "pull," but still not enough to be useful. You can use the wire to make a magnet that has much stronger pull without increasing the amount of electricity flowing through the wire.

To make such a magnet, you will need about 25 feet of enameled or Nyclad copper wire (size 24, 26, 28, or 30), which you can get from a hardware or electrical supply store. You will also need a nail or stick about one-eighth of an inch

with ELECTRICITY

by Paul Bethune

in diameter and a flashlight battery (or the larger No. 6 dry cell battery).

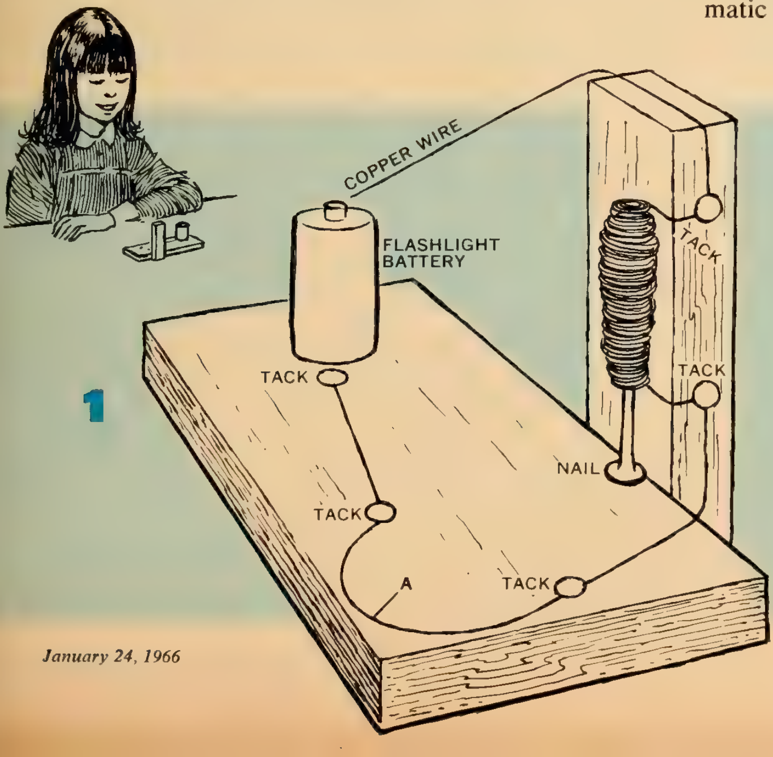
Scrape the enamel coating off one-half inch of the wire at each end. Then wind the wire around the nail in as many layers as possible, leaving about six inches of wire unwound at each end. Carefully remove the nail from the coil to leave a smooth, round hole through the coil. Then nail or glue two pieces of wood together as shown in Diagram 1. Mount the coil so that the end is about one-half inch above the wooden base. Find another iron nail that is a little longer than the coil, but thin enough to fit inside the hole without touching the coil. Put the nail in the coil as shown. About half of the nail should be inside the coil. Now, hold the bottom of the battery against the tack at one end of the wire and touch the other end of the wire to the center of the top of the battery. The nail should be drawn up into the coil as the current from the battery flows through the wire.

What happens when you lift the wire off the battery? Try sending quick spurts of electricity through the coil. Quickly touch the wire to the battery and lift it away a number of times. Can you keep the nail moving in this way?

From Magnets to Motors

If you had to keep switching the current on and off to keep a motor moving, it wouldn't be much help. But you can make the magnet switch itself on and off automatically. Simply cut the wire at point A *(Diagram 1)*, scrape the coating off a half inch of each of the cut ends, and bend the two ends so they cross each other directly beneath the nail *(see Diagram 2)*. Bend the top wire so that it does not quite touch the bottom wire. Then connect the battery. If the crossed wires are in the right position, the nail will move up and down rapidly, switching the electricity on each time the nail head pushes the two wires together, and switching it off each time the nail is pulled up.

In the electric motors that move so many things in your house, the shaft turns round and round instead of jumping up and down. But they all have wire coil magnets and automatic switches to keep the shaft turning around ■



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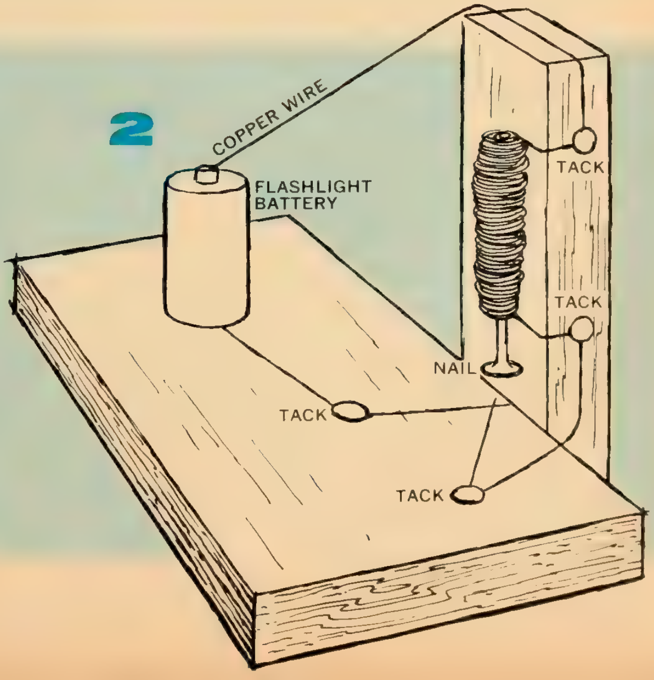


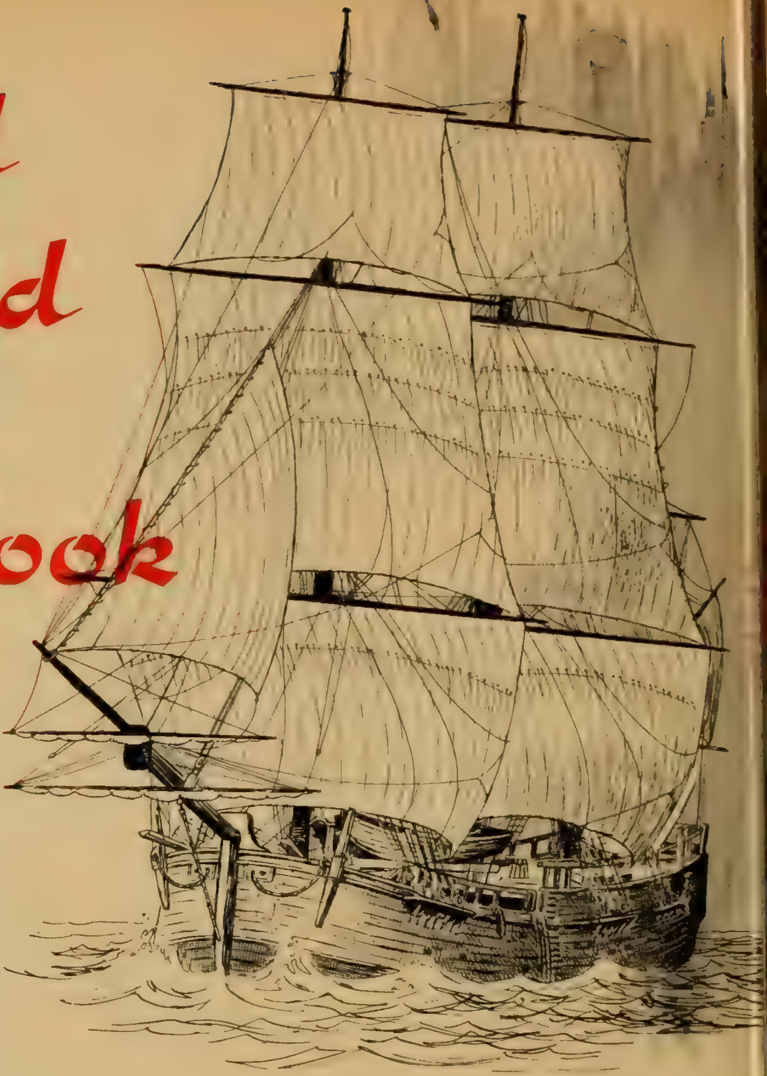
2

Around the World with Captain Cook

by Jean Le Corbeiller

PART 1

● **In 1768, Captain James Cook and a party of scientists sailed from England to the South Pacific to observe a rare event in the sky. He also had secret orders to sail uncharted waters in a search for a mysterious "Great Southern Continent."**



H.M.S. *ENDEAVOUR*

■ On August 26, 1768, a small three-masted sailing ship, H.M.S. *Endeavour,* sailed out of Plymouth, England, and headed for the open Atlantic. There were 94 men aboard, including a party of 11 scientists. Among them was the 25-year-old botanist, Joseph Banks. The ship's captain was Lieutenant James Cook, who carried secret sealed orders from the British Admiralty.

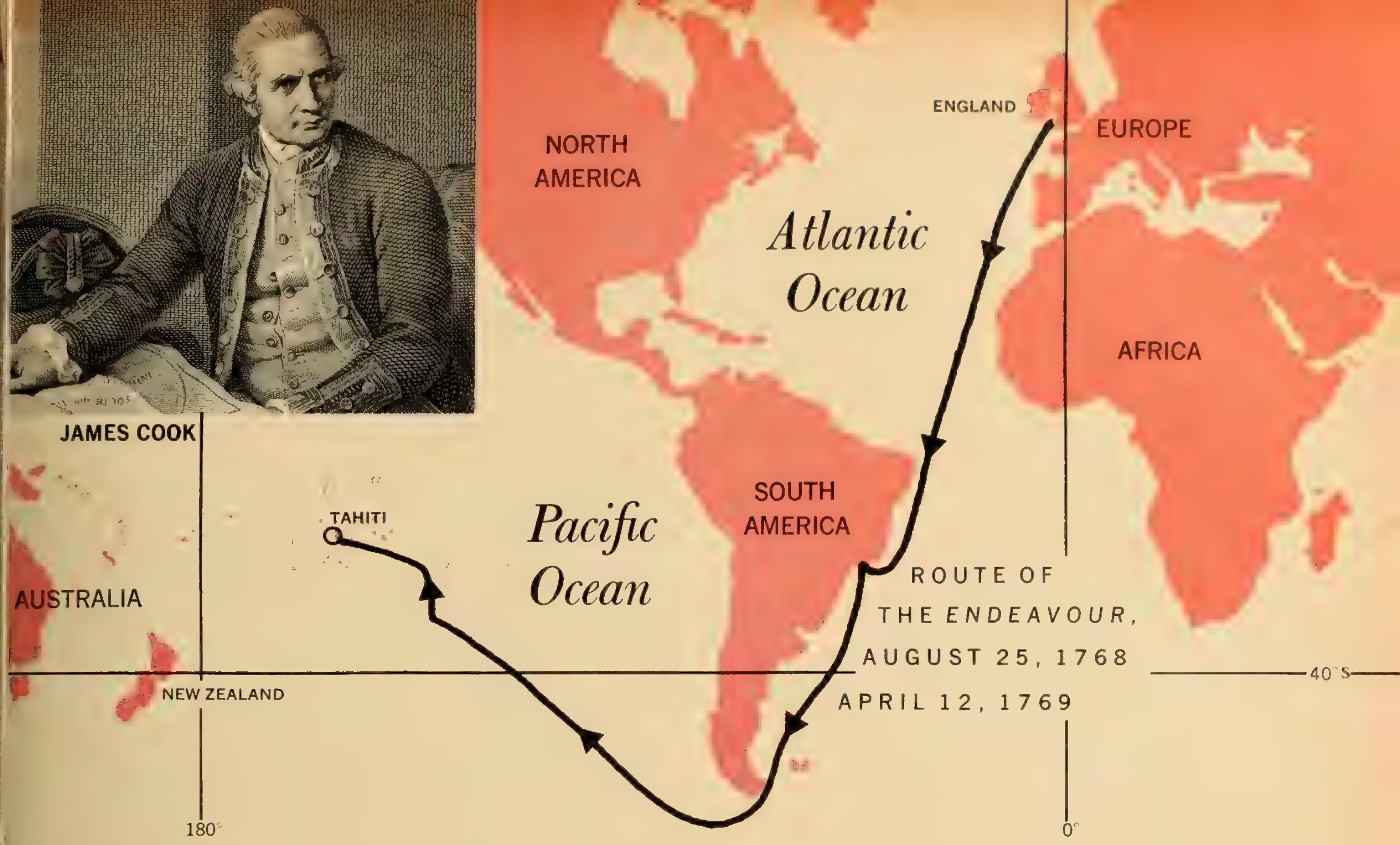
Cook's orders amounted to this: He was to sail to the island of Tahiti—in the South Pacific—by rounding the tip of South America. He was to reach Tahiti at least a month before June 3, 1769. On that date he and the members of the scientific staff were to observe a rare astronomical event—the *transit,* or passing, of the planet Venus across the sun's disc. Next, he was to sail south (as far as 40° South Latitude) in search of the mysterious Great Southern Continent—a huge land mass which geographers of the time thought must exist in the Southern Hemisphere. If it was not found, Cook was to sail west until he reached the unknown east coast of New Zealand. He was to explore the coasts of New Zealand as fully as possible and then return to England.

The Secret Mission

The first part of Cook's orders—observing the transit of Venus—was public knowledge. The second part—exploration for unknown lands—was secret. In Cook's time the vast Pacific Ocean was almost entirely unknown. Forty years earlier, Jonathan Swift had written *Gulliver's Travels,* stories of imaginary lands and people. A land of giants, another of crazy scientists, and another of tiny people were all to be found somewhere in the Pacific Ocean. Swift could write freely about the Pacific because vast reaches of it had never been crossed.

The British Admiralty wanted to know what land might be found—and claimed as a British territory—in these vast stretches of ocean, and it was determined to find out. Once Cook had rounded the tip of South America, he headed northwest then westward toward Tahiti *(see map).* In doing so, he sailed right across areas where mapmakers thought the Great Southern Continent was.

Cook had no great difficulty knowing how far north or south he was. He merely had to note how high above the horizon certain stars were at night. But knowing how far



west he had gone was much more difficult. If you notice which stars are exactly overhead at midnight, you can tell how many degrees you have traveled west of the prime meridian, located at Greenwich, England *(see map)*. But during this voyage, Cook had no way of knowing exactly when midnight (or any other time) occurred. Clocks then available to him simply did not keep accurate time over a period of many weeks or months. An error of 10 minutes in time meant an error in east-west distance, or *longitude*, of about 150 miles!

Telling Time by the Moon

Until clockmakers produced a really reliable ship's clock, navigators far from land had to estimate the time by other means. Cook used tables showing how the moon changed position from night to night, as seen from Greenwich. To tell time, then, Cook noted how far "behind schedule" the moon seemed to be, then he could calculate how many degrees west of Greenwich he was.

The *Endeavour* reached Tahiti on April 12, 1769, allowing the group almost two months to get ready for the transit. Cook and his party went ashore and made friends with the Tahitians. He then settled on a spot for his encampment, to this day still called Point Venus on maps. His men built a camp and surrounded it with a picket fence.

The transit was to occur June 3rd. Astronomers were interested in transits of Venus because they provided a way of measuring the distance of the earth from the sun. The word *transit* comes from the Latin word for "passage." When a transit of Venus takes place (only twice every 113 or 130 years), Venus appears as a black dot crossing the face of the sun.

The transit of 1769 was to be observed by astronomers the world over—in St. Petersburg, Russia; in Cape Town, near the southern tip of Africa, and many other places. Cook's voyage to the Pacific was regarded of great importance because it would provide an observatory in a part of the world almost impossible to be reached by astronomers.

Everything was going well, when an alarming discovery was made. One of the expedition's key instruments had disappeared It was a large brass *quadrant*—a kind of protractor for measuring angles in the sky. Cook suspected the Tahitians, but what possible use could they find for a quadrant? They saw it as a glorious, shiny contraption so perfect that it must be magical. Although Captain Cook and Joseph Banks were living in the 1700's, the Tahitians were still living in the stone age. Cook sent out search parties, and before nightfall the quadrant was found. It was slightly damaged, but one of the men on Banks' staff repaired it.

The Troublesome Transit

The day of the transit was a great moment for Cook. He was a man who had risen from simple seaman on a merchant ship to leader of his country's Pacific expedition.

(Continued on the next page)

His own report—old spelling and all—reads as follows:

SATURDAY 3rd. This day prov'd as favourable to our purpose as we could wish, not a Clowd was to be seen the whole day and the Air was perfectly clear, so that we had every advantage we could desire in Observing the whole of the passage of the Planet Venus over the Suns disk; we very distinctly saw an Atmosphere or dusky shade round the body of the Planet which very much disturbed the times of the contacts particularly the two internal ones. Dr. Solander observed as well as Mr. Green and my self, and we differ'd from one another in observing the times of the Contacts much more than could be expected.

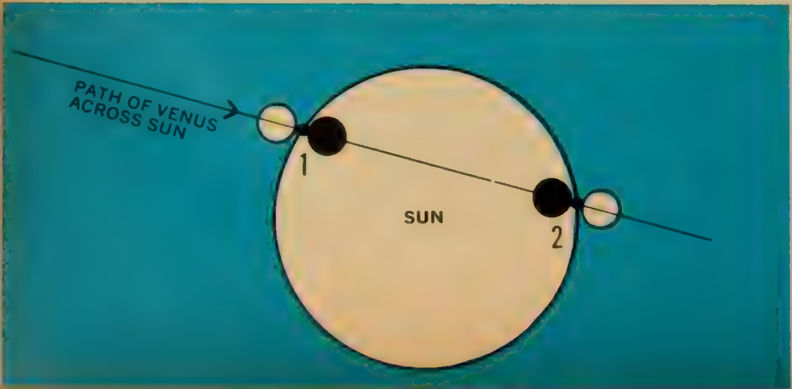
What Cook was observing (and timing) was not one event but two *(see diagram)*. The problem was knowing exactly at what moment the trailing edge of Venus was even with the edge of the sun's disc (position 1), and at what moment the forward edge of Venus began to cross the opposite edge of the sun's disc (position 2). The trouble is that at each moment of "contact," as Cook called it, a little bridge of black suddenly appears and joins the black disc of Venus to the vast black space around the sun. This is an optical effect. Neither Cook nor any of the other observers around the world could decide at just what moments the dark disc of Venus and the bright disc of the sun were exactly touching.

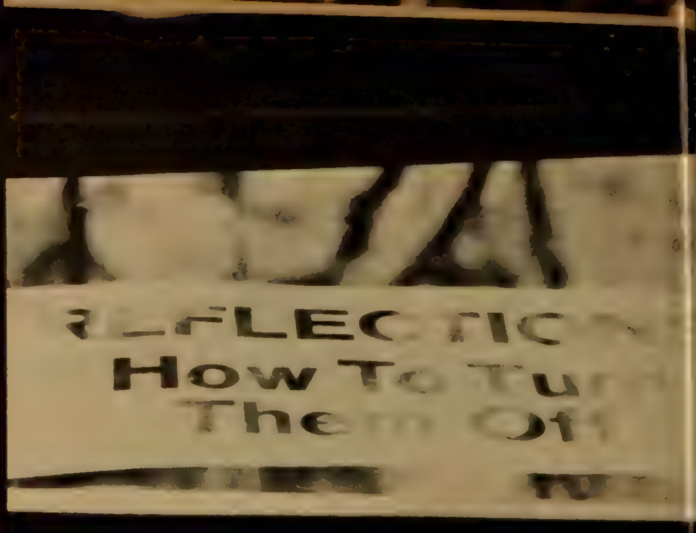
As a result, the transit timings sent in by Cook and the others were so different that it was difficult to know the exact length of time of the transit. Two generations later, the German astronomer J. F. Encke pored over all the transit observations. After much juggling of figures, he concluded that the distance of the earth from the sun was a little more than 95 million miles. Encke's figure stood as the best one available for many years.

Cook's astronomical work was now over, and his exploring could begin. What the Admiralty had instructed him to do next was discover how far south and east New Zealand extended. But what was really on everyone's mind was the exciting question of the existence of the Great Southern Continent ■

In the next issue, Captain Cook sails into a trap.

When Venus passes (1) on to and (2) off the sun's disc during transit, a black dot links the edge of Venus to the edge of the sun. This is called the "black-drop" effect.





by David Linton

Light reflected from the surface of the water in this
to makes it hard to see the message in the water clea

■ You have probably seen the special kind of sun glas
called "Polaroid" glasses. The eyes of bees and Polar
lenses work in the same way. They both cut glare. H
are some investigations you can try with these glass

Look at the surface of a lake or pool or the top of
aquarium. You may see reflections that sparkle and sh
mer, and the water may look blue because the blue sk
reflected in it. What happens when you put on a pair
Polaroid glasses? (You can see why fishermen often w
glasses like this.)

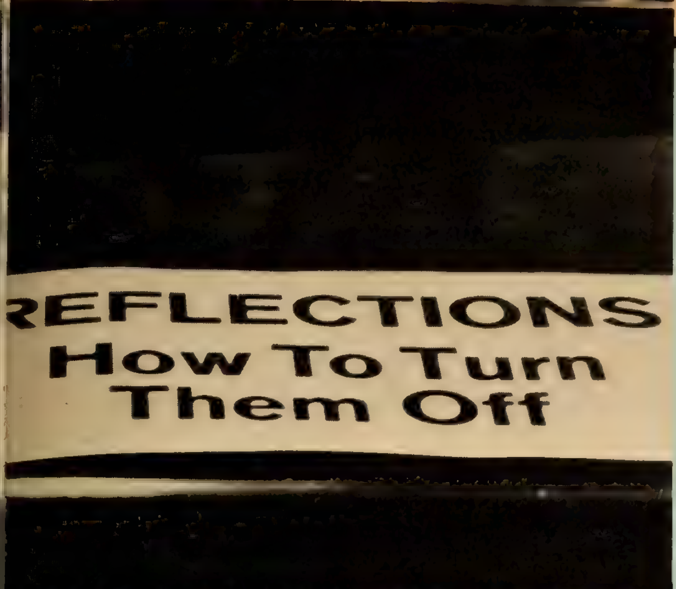
Now take the glasses off and hold them in front of y
eyes. Look through one lens at the surface of the wa
and slowly twist the glasses until they are upside do
What happens? Somehow the glasses separate the light t
bounces off the surface of the water from the light t
lets us see what is under the water.

Now borrow another pair of Polaroid glasses and h
them one behind the other, so that you can look throu
two lenses with one eye. As you look through the lens
slowly twist one of them. At one point almost no light
all comes through the lenses.

Making Model Waves

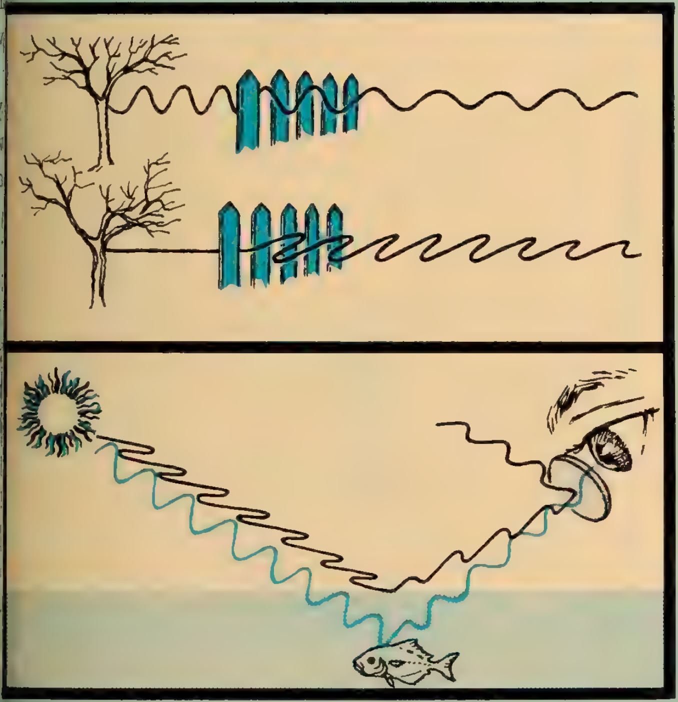
To find out how Polaroid lenses work, you can use
piece of clothesline rope to make a model of light. Li
travels in waves. If you fasten one end of the rope to
doorknob or a post and flip the other end up and dow
you can make waves in the rope. You can also make wa
that go from side to side, or on a slant. Light waves fr
the sun or a lamp move in all directions.

Now imagine that your rope is threaded through so
sort of slot—say the space between two pickets in a fe
(see diagram). Waves that go up and down will pass throu



this photo, a Polaroid lens blocked reflections from ne surface of the water, so you can see the message learly.

he slot, but waves that move from side to side or on a lant will not. If the pickets were turned so that the space etween them ran from side to side, only side-to-side waves ould pass through them. Up-and-down waves would not. olaroid glasses work in much the same way as the picket ence. Only light waves that move in one certain way can pass through these glasses; the other waves are blocked.



Light travels in waves similar to ocean waves. But, unlike water waves, light waves can go from side to side as well as up and down. Side-to-side light waves bounce off a pond but are blocked by a Polaroid lens. Unlike side-to-side waves, up-and-down waves (blue) pass through water, bounce off a solid object, and pass through the Polaroid lens.

The surface of a pond also works this way. Light waves that move up and down pass through the surface of the water, but waves that move from side to side are blocked. The side-to-side waves bounce off the surface, causing reflections. When you are wearing Polaroid glasses, the side-to-side waves are blocked, and only the up-and-down waves reach your eyes *(see diagram).*

The Two-Lens Blackout

When two Polaroid lenses are lined up in the same way, light waves moving in one direction—say up and down—pass through both lenses. But if one lens is turned so that only side-to-side waves pass through it and the other lens is turned so that it lets only up-and-down waves pass through, no light at all reaches your eye, so the lens nearest your eye looks black.

Light that has been filtered or reflected so that all the waves move back and forth in the same direction is called *polarized* light. Much of the light that comes from the blue sky is polarized. You can see this if you stand in an open place on a clear day. Hold your Polaroid glasses about 6 inches from your eyes, and tilt them so that one lens is higher than the other. Then look at the sky through one lens while you slowly turn around.

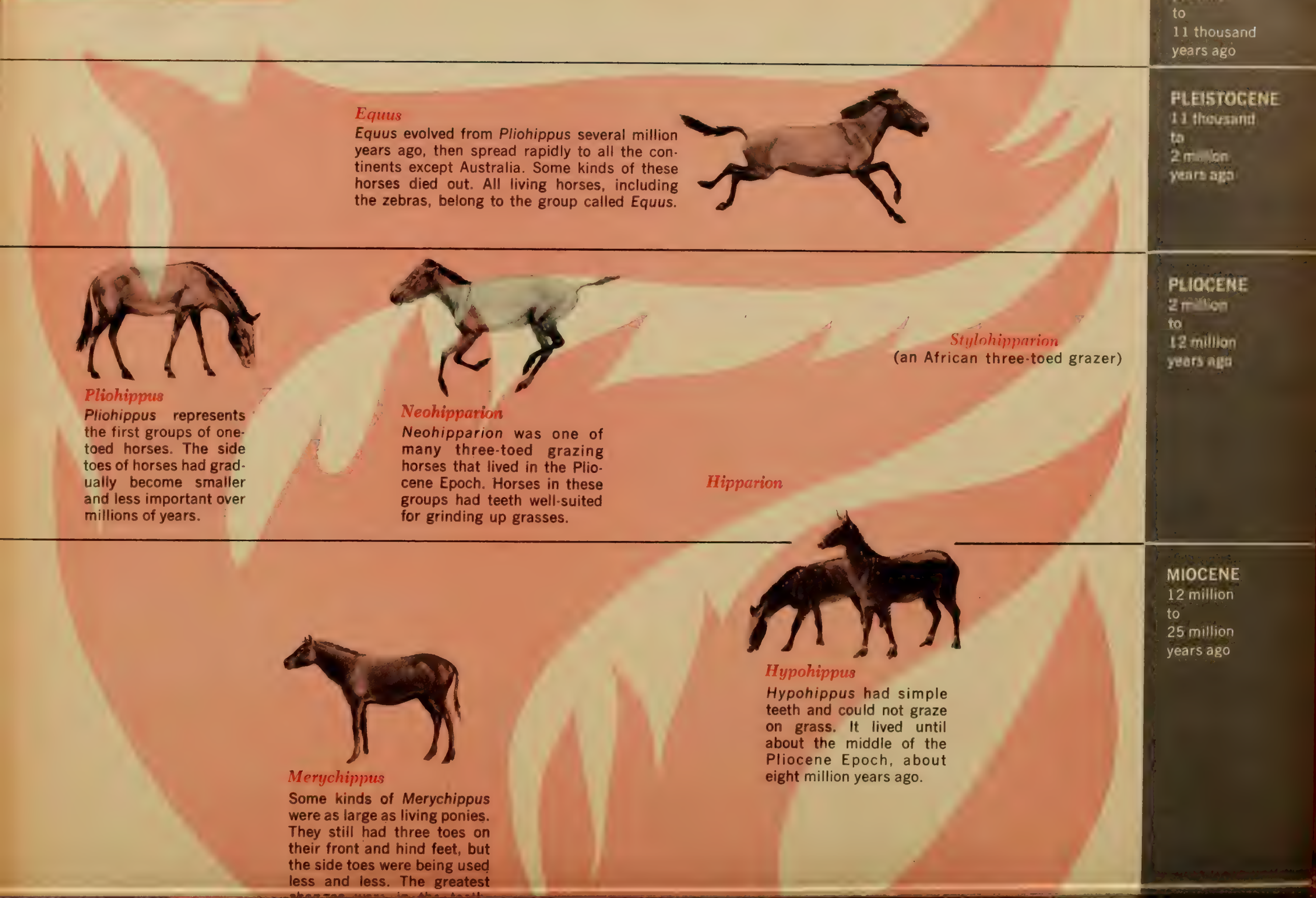
Some parts of the sky will look darker than others through the lens. This is because most of the light reaching you from the dark-appearing parts of the sky is polarized. If you do this in the late afternoon when the sun is in the west, you will find that the darkest-appearing parts of the sky are to the north and south. The polarized parts are always one-quarter and three-quarters of the way around the sky from the sun.

Scientists have discovered that bees use polarized light from the sky to find their way back to their hive.

Polarized light looks just like ordinary light to us, but scientists and photographers *(see photos)* find that they can do things with it that they can't do with ordinary light ■

INVESTIGATIONS

- To see an object, your eyes must receive light that has been reflected from the object to your eyes. Have you ever walked into a glass door because you didn't see it? Can you explain why you didn't see it?
- Objects that have a smooth surface reflect more light in the same direction than objects with a rough surface do. Do you think that some of the light that is reflected by a glossy leaf, or an automobile top, for example, is polarized? Can you think of a way to find out?



RECENT
present
to
11 thousand
years ago

PLEISTOCENE
11 thousand
to
2 million
years ago

Equus

Equus evolved from *Pliohippus* several million years ago, then spread rapidly to all the continents except Australia. Some kinds of these horses died out. All living horses, including the zebras, belong to the group called *Equus*.

PLIOCENE
2 million
to
12 million
years ago

Pliohippus

Pliohippus represents the first groups of one-toed horses. The side toes of horses had gradually become smaller and less important over millions of years.

Neohipparion

Neohipparion was one of many three-toed grazing horses that lived in the Pliocene Epoch. Horses in these groups had teeth well-suited for grinding up grasses.

Hipparion

Stylohipparion
(an African three-toed grazer)

MIOCENE
12 million
to
25 million
years ago

Merychippus

Some kinds of *Merychippus* were as large as living ponies. They still had three toes on their front and hind feet, but the side toes were being used less and less. The greatest

Hypohippus

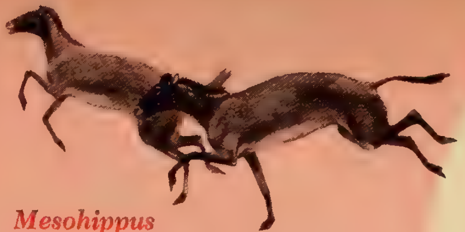
Hypohippus had simple teeth and could not graze on grass. It lived until about the middle of the Pliocene Epoch, about eight million years ago.

The Horse's First 55 Million Years

Parahippus

North America to Europe and Asia)

Miohippus



Mesohippus

Mesohippus had just three toes on both its front and hind feet. It was bigger than eohippus and had a larger brain. Like eohippus, its teeth were not suited for chewing grasses.

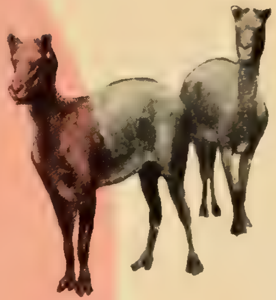
OLIGOCENE
25 million
to
40 million
years ago

Epihippus

Orohippus

Eohippus

Eohippus, or "dawn horse," is the common name for the first horses. Some were as small as a fox terrier; others were about half the size of ponies. They probably ate leaves of trees and shrubs and ran about on little hooves, four on the front feet, three on the back. Most of their weight, however, was supported by pads on their feet.



EOCENE
40 million
to
55 million
years ago

EPOCH

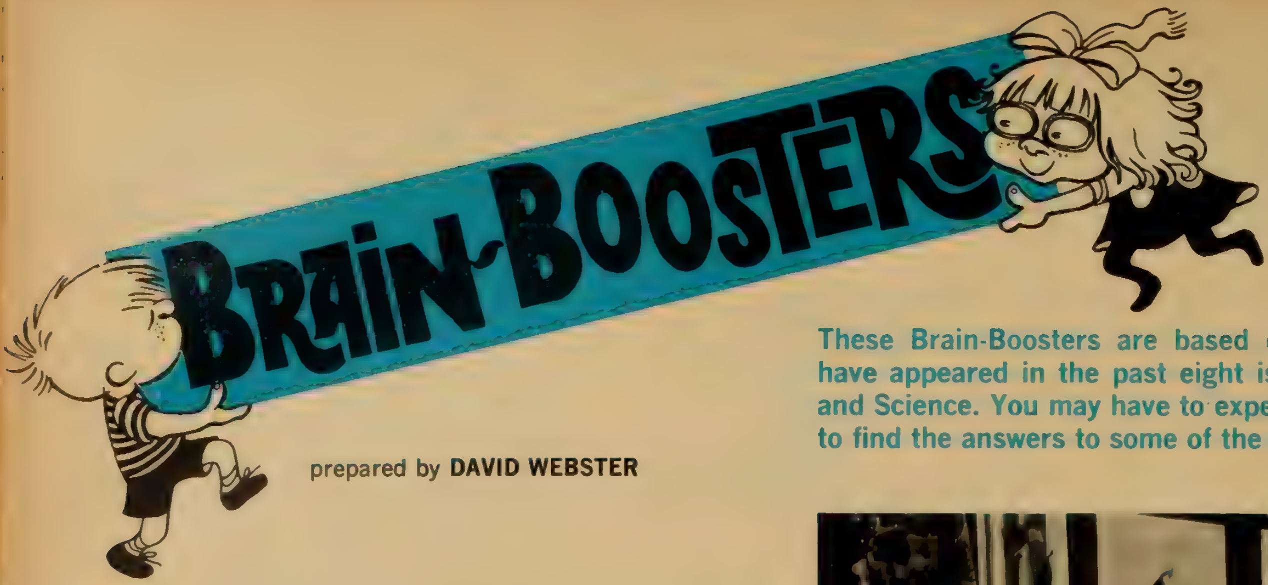
■ By studying fossils, scientists have pieced together a picture of how the horse has evolved. Even so, some challenging puzzles remain.

Where did the first horses come from? No one knows. And what happened to the vast herds of horses that roamed the plains of North and South America just 10,000 years ago? They all died out and no one knows why.

The drawings on these pages show something of what *is* known about the evolution of horses. Since their beginning about 55 million years ago, horses have changed from small, fox-sized animals to the big animals you know today. But this is only a part of the story of their evolution.

There is no straight line between early horses and today's horses. For every horse shown on these pages, there are dozens of others that were different. While some kinds gradually became bigger,others became smaller, or didn't change in size at all. As the chart shows, there are many side branches on this "family tree." They show when different groups of horses died out. To trace the highlights of horse evolution over the years, begin at the bottom of the chart ■

BRAIN-BOOSTERS

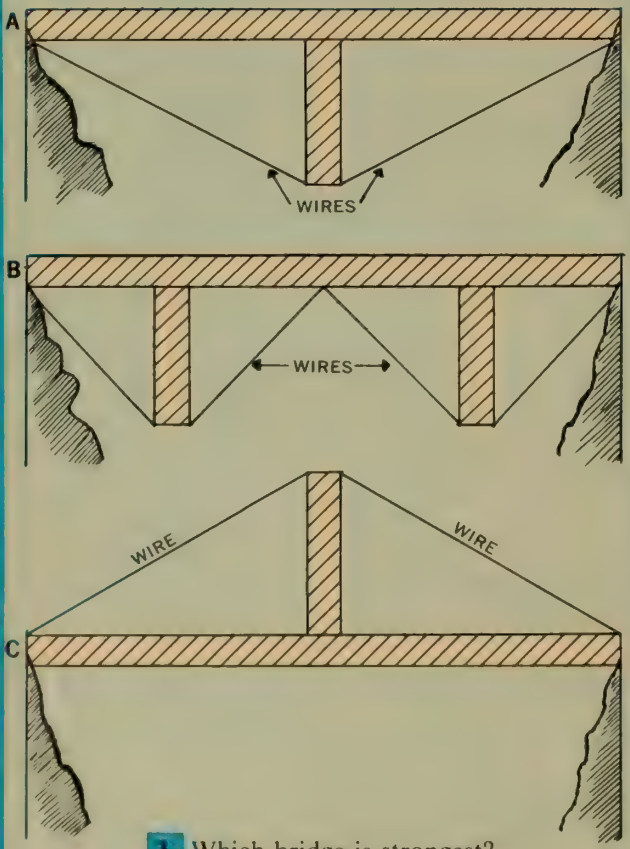


prepared by **DAVID WEBSTER**

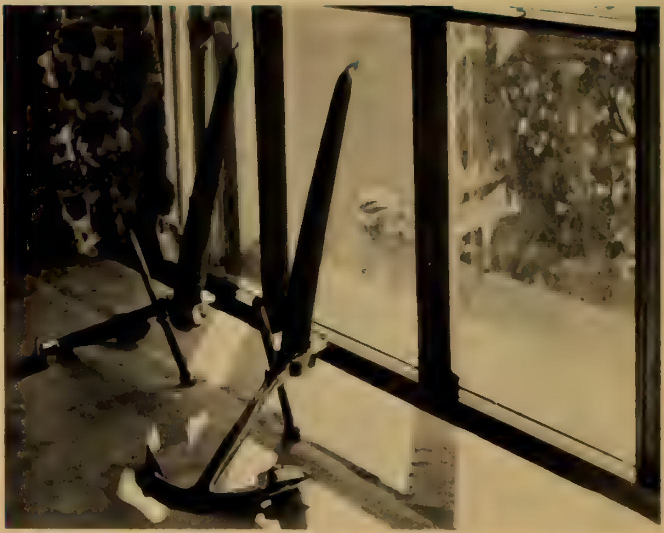
These Brain-Boosters are based on articles that have appeared in the past eight issues of Nature and Science. You may have to experiment, though, to find the answers to some of the questions.

1. Just for fun, *plant* a bird nest. Seed-eating birds often drop some seeds in their nests. There are also seeds in many nests on the materials used to make them. Find an abandoned bird's nest, cover it with dirt, and keep it watered. Do any plants grow? What kind are they?

2. You have probably noticed colored oil on a wet street. What kind of oil makes better rainbows, new oil or old oil? (You can get old oil off the *dip stick* in your car.)

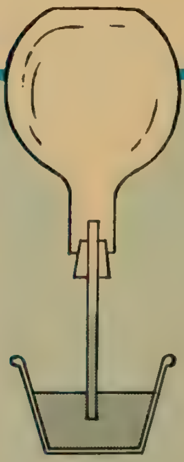


3. Which bridge is strongest?



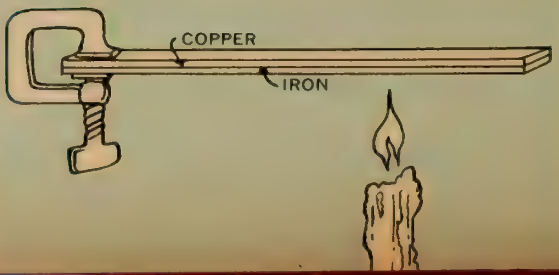
4. What has caused the candles to lean toward the light? (Is it for the same reason that plants grow toward light?)

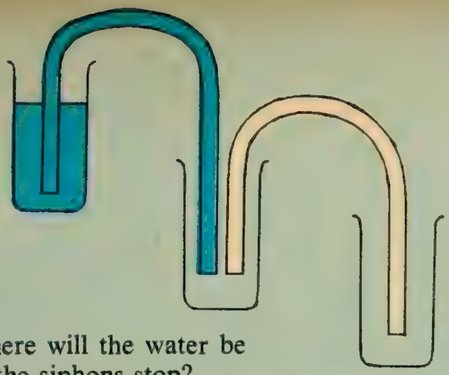
5. The lens of a camera makes an image on the film that is upside down. Why is it, then, that photographs are not upside down?



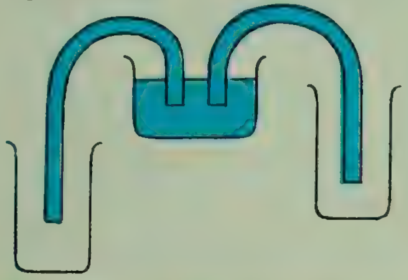
6. When this air thermometer is heated, will the liquid go up or down?

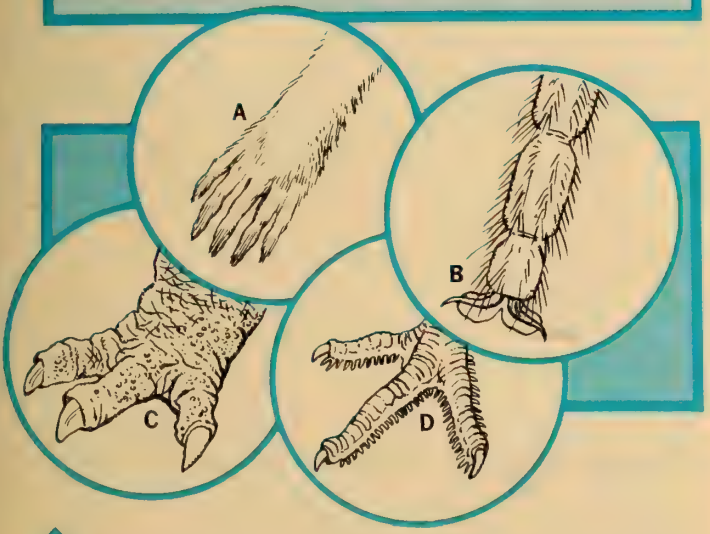
Which way will the bar bend when heated, up or down?



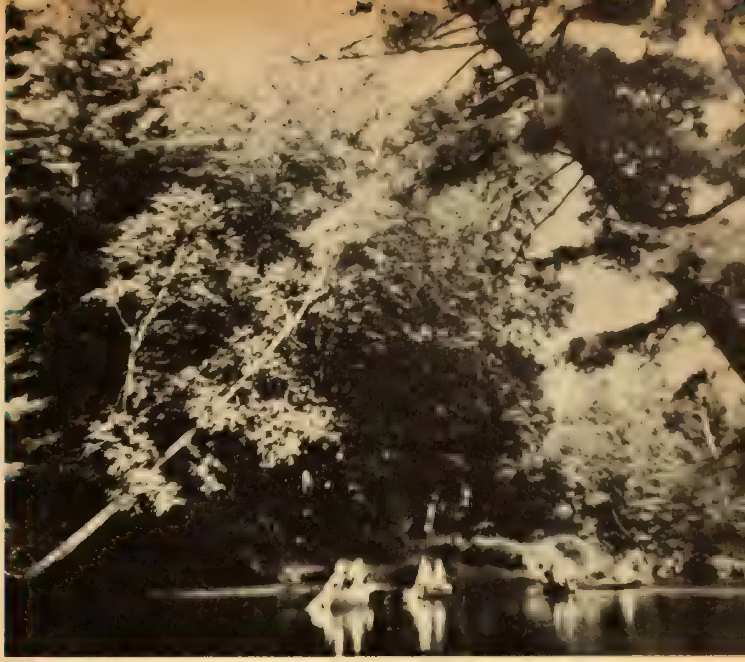


7. Where will the water be when the siphons stop?



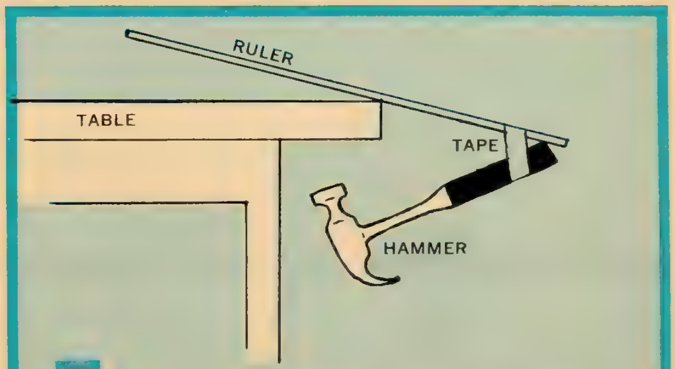


8. Here are the feet of four animals that have been written about this year in *Nature and Science*. To what animals do the feet belong? (All the feet are drawn the same size, but some are really much bigger than others.)



9. What has caused these trees to lean?

10. Have you ever dug a hole and then filled it back in with the same dirt? Usually there is not enough dirt to fill the hole completely. Do you know why?

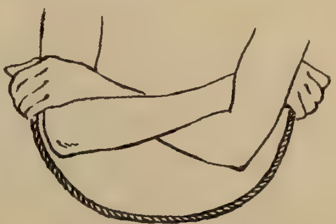


11. See if you can make a ruler and hammer balance like this. Why doesn't it fall off the table?

ANSWERS TO BRAIN-BOOSTERS IN THE LAST ISSUE

Mystery Photo: The skulls of two small birds, a mouse, and a shrew are among the bones taken from the owl pellets.

Can You Do It? To tie an overhand knot, cross your arms before picking up the rope. Then unfold your arms and you will have a knot in the rope.



What Will Happen If...? The ruler will hit the floor first.

Fun with Numbers and Shapes: Here are the completed number sequences. In the last sequence, each number is the sum of the two numbers before it.

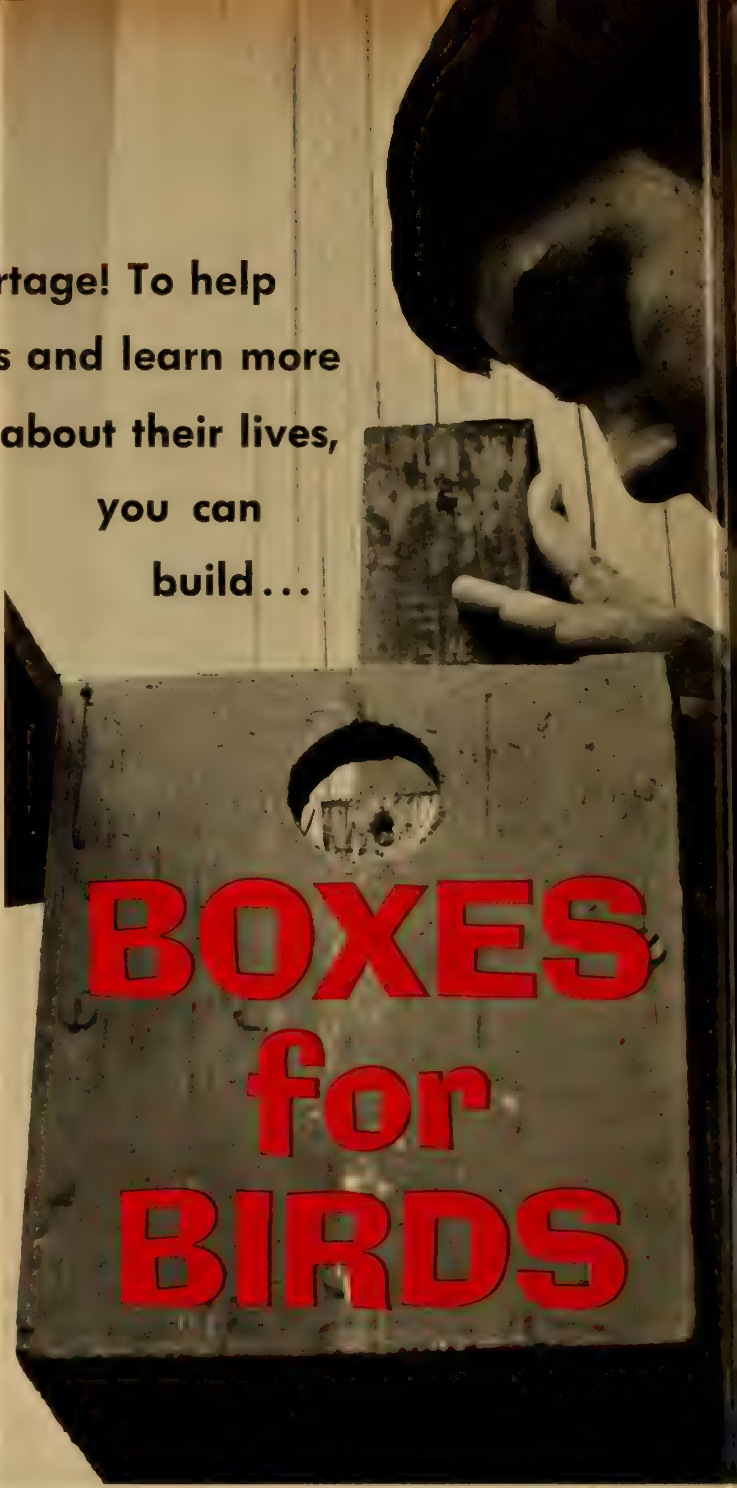
1 4 7 10 13 16 19
1 2 2 3 3 3 4 4 4 4 5
1 3 4 7 11 18 29 47 76 123

For Science Experts Only: The higher balloon is black and the lower one is white. The black balloon absorbs more heat, which causes its hydrogen to expand more and makes the balloon rise higher.

Some kinds of birds are faced with a big housing shortage! To help these birds and learn more about their lives, you can build...

BOXES for BIRDS

by Rod Cochran



■ A male bluebird was diving at us, flashing just inches from our heads. But my companions and I took another cautious step toward the nest box and lifted the lid. Three little bluebirds looked up at us.

"This is the second nesting for this box," said Bill Highhouse, of Warren, Pennsylvania, whose hobby is putting up bird houses. "When these birds fly away in a few days, a total of seven will have been raised here this year."

We set off to look at more bird houses. It was high adventure to see what each box held. It's fun to put up bird houses—one of the first conservation efforts man attempted many centuries ago. Many people are still doing it all across the country.

But do birds really need houses put up for them? The answer all across the country is *yes*. They are needed today more than ever before. Birds that nest in holes in trees are faced with a "housing shortage." Wooden fence posts with holes in them used to furnish homes for woodpeckers, bluebirds, and tree swallows. Now the wooden posts are replaced with steel ones. When English sparrows and starlings were brought to this country, they began to compete with native birds that nest in holes. They often drive native birds out of holes.

The eastern bluebird has been particularly hard-hit by a lack of nesting places. And, in recent years, cold, ice, and snow during spring migration have killed thousands of bluebirds. Some *ornithologists* (scientists who study birds) are worried about the low numbers of bluebirds. How can the birds recover when there are so few nesting places?

One Person Can Do a Lot

In 1957, Bill Highhouse decided to give the bluebirds some help in Pennsylvania. He salvaged some scrap lumber, built five houses and took them out along a road that runs through farms and abandoned land. Here, where open fields are sprinkled with trees and shrubs, he began nailing the houses to posts. After finishing, he started home, and on the way he saw a bluebird sitting on the first house he had put up!

Bill Highhouse did not know it at the time, but he had started a hobby that now takes much of his spare time the year around. He built and put up 74 houses that first year. They produced 34 successful broods for an estimated total of 119 birds. Three of the broods were tree swallows; the rest were bluebirds.

The following season he put up and checked 80 boxes, which produced 160 birds. In attempting to bring back the bluebirds, Bill Highhouse has helped increase the tree swallow population too. In 1965, his 83 bird houses produced 590 bluebirds and 118 tree swallows.

With the aid of friends, including 11-year-old Mike Menard (*see photo above*), Bill Highhouse has helped bring bluebirds back to Warren County. Thanks to the work of these people, bluebirds were plentiful there even in 1962, when bad weather wiped out these birds in many areas.

Similar projects are under way in other parts of the United States. The Bluebirds Unlimited Program of the Grand Rapids (Michigan) Audubon Club is a good example. In three years this group has built and distributed over 5,000 houses. In Leelanau, Michigan, Boy Scout Troop 29 has won six national awards for their work in building and putting up more than 13,000 bluebird houses.

Homes for Other Birds

More than 50 different kinds (*species*) of birds have been known to nest in man-made structures. And there are other species besides bluebirds that need help. One is the redheaded woodpecker. They prefer high houses (12 feet or more above the ground) and entrance holes that are two inches wide. Unfortunately, this makes a bird house perfect for starlings. If the house is placed far from buildings, however, starlings usually will not bother it.

Purple martins nest in colonies. They need apartment houses high atop a pole in an open area. But English sparrows often move into these houses and become pests.

The beautiful wood duck, which usually nests in hollow trees, was once thought to be on its way to extinction. But nesting box projects have helped bring it back in good numbers. State conservation departments led the way, with sportsmen's groups and other people pitching in to help.

Any person can help ease the bird house shortage by building a single house and putting it in a suitable place. All sorts of materials have been used for houses, but wood is best and easiest to work with. You should build the house tight enough so that rain water does not pour in, although birds can protect themselves from a few drops. Drill some small holes in the bottom so that any moisture that gets in can drain away. The roof should overhang the entrance to keep rain from coming in.

By building and watching bird houses, you can learn a lot about the lives of birds. Mr. Highhouse takes notes on the young birds that are raised in his bird houses.

Painting or staining the bird houses makes little if any difference to the birds. However, paint protects the wood. Don't put up newly painted or stained houses until the paint odor is gone. Houses for purple martins, or others that are exposed to the full heat of the sun, should be painted white to reflect heat. Other houses can be painted gray, green, or brown.

The inside of a bird house can get nearly as hot as the inside of a closed automobile in the summer. To protect eggs and nestlings from this heat, drill two or more ventila-

(*Continued on the next page*)

No birds nested in this house, so Mr. Highhouse is putting it up in a new spot. Notice the ventilation holes drilled near the top of the house's side. The top of the house is hinged so the inside can be easily cleaned and observed.

tion holes near the top of the house (*see building plans below*).

Keep in mind the needs of the kind of bird you want to attract. A wren house, for instance, seems to be more attractive to wrens if it is on the side of a garage or house. Robins usually don't nest in bird houses but will build their nests on open platforms. A platform for robins can be placed in a living tree, for they nest there naturally. For many other kinds of birds, a fence post or pole that is several feet away from trees is a good place to put a nesting box. You will find other tips for building and erecting bird houses in the books and pamphlets listed at the end of this article.

Spying on Birds

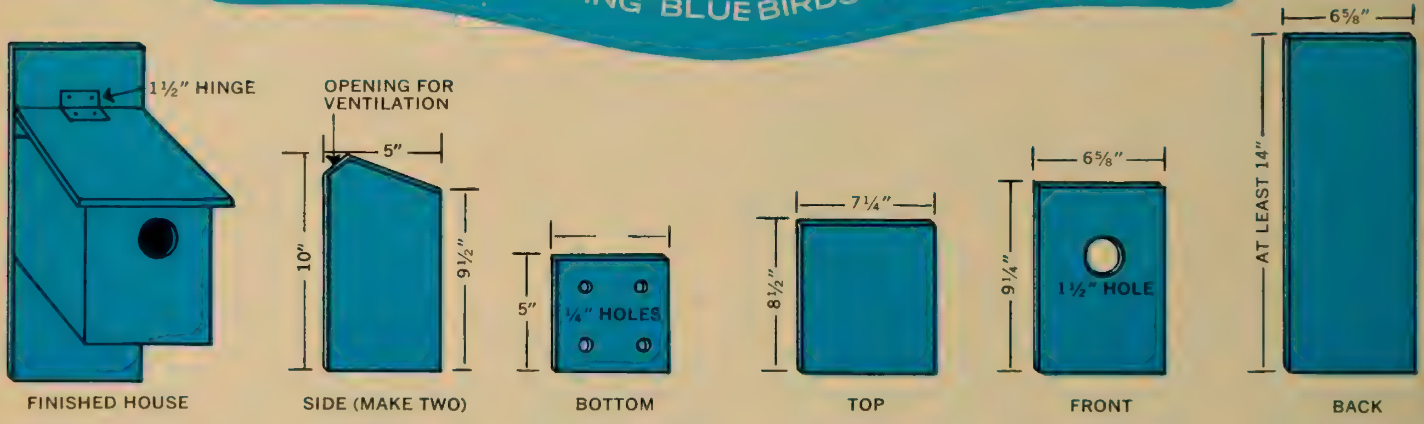
Winter is the time to begin building and putting up bird houses. Spring is coming, and bluebirds, for example, begin their northern migration in March. The houses should be ready for them when they arrive.

Keep a watch on the houses you put up. Notice how many different species of birds visit the house. Is there any fighting over the house? What kind of bird builds a nest there?

Keep a record of when the nest is started and the number of days needed to complete it. Don't disturb the nest very often, but find out how many eggs are laid, how many hatch, and if all the young survive to leave the nest. Once the nest is abandoned, remember to clean out the bird house. Is there a second nesting? Keep notes on what you see. You may discover something new to science ■

■ For more information about bird houses, send for Conservation Bulletin 14, **Homes for Birds,** available from the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (15 cents). Also look for these books in your library or bookstore: **Songbirds in Your Garden,** by John K. Terres, Thomas Y. Crowell Co., New York, 1958, $4.95; and **Field Book of Nature Activities and Conservation,** by William Hillcourt, G. P. Putnam's Sons, New York, 1961, $4.95.

TIPS FOR HELPING BLUEBIRDS IN YOUR AREA



If you want to put up one or more bluebird houses, here are some pointers from Mr. Highhouse:

- If you live in a city, do *not* put a house in your backyard. Bluebirds live in fields, orchards, and along the edge of woods. Place your house or houses in these locations. If you ask, most farmers will gladly allow you to put up bird houses on their land.
- The design and appearance of the houses is not important as long as they are the right size (*see plan*). The houses should also have an entrance no larger than 1½ inches wide (to keep out starlings), and should be weatherproof. They *do not* need a special place for the bird to perch.
- The house should be placed about four or five feet up on a post. This makes them easier to look into and clean. It discourages English sparrows and starlings, which prefer to nest higher.
- Do not place houses too close together. Bluebird houses should be at least 300 feet apart.
- Dust the nests and eggs with a mild insecticide to kill ants and other insects that may harm young birds. Flea powder that is recommended for cats is satisfactory.
- Clean out the boxes in spring before the birds arrive to nest. Then clean them again after the first brood has left. A second brood may then be raised in the same house.
- Vandalism can be a problem, so place houses where they are not easy to see from a road.

seeing more with your MICROSCOPE

With everyday objects like onions and hairs, you can explore and measure in the micro-world.

by
MARIANNE POLACHEK

■ You can see beautiful and unexpected sights by looking at little things through the lens of a microscope. If you don't have a microscope, you can build your own *(see "Make Your Own Microscope,"* N&S, *Dec. 6, 1965).* You'll discover amazing things even in common, everyday objects. Take an onion, for instance.

Have you ever looked at an onion closely? When you cut one lengthwise, how many layers do you see? Are they all the same size? What differences do you see in them?

Now cut the onion crosswise and look at the layers with a magnifying glass. Pick up a layer with a pair of tweezers. (If the strong smell of onion bothers you, use a paper towel to dry the cut edges of the onion.) Then, with the tweezers, gently pull on the skin of the next layer, and get a piece of very fine layer *(see Diagram 1)* to look at under a microscope.

Put the onion skin on a slide as quickly as you can, for it rolls up. (You can make your own slides and cover slips from stiff clear plastic. Sometimes boxes of toys or writing paper have tops of this plastic.) Spread the onion layer on the slide. Put a drop of water on it. Touch the edge of a cover slip to the water and gently lower the rest of the cover slip over the onion layer *(see Diagram 2).* Now put the slide on your microscope and look at the onion.

Inside an Onion

Tilt the mirror of your microscope back and forth. How does the layer look in bright and in dim light? Do some parts stand out in both the dark and the light?

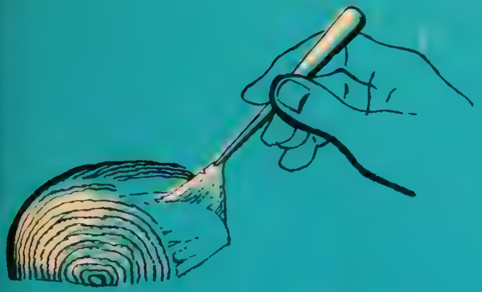
What are the shapes of the little units you see? Are they all the same size? The man who first saw them thought they looked like *cells* in a prison, and that is how they were named. Do you see anything inside the cells?

Do you think other parts of the onion would look the same under the microscope? Look at a thin layer from the center, and one from the outside. What do you see? Are all the cells about the same size?

You may have an onion at home that has sprouted, with little roots coming out of one end and leaves beginning to come out of the other. (If you set an onion in water, it will sprout in two or three weeks.) What does a tiny bit of root from an onion look like under the microscope? Look at a thin layer of cells from a leaf. What differences do you see? Are the leaf and root cells alike in any way?

Are all onion cells the same size? How can you measure

(Continued on the next page)



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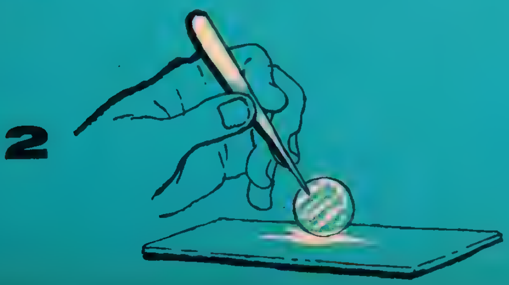


2

1. Use tweezers to get a very thin layer of onion.

2. Then put the thin layer on a microscope slide, put a drop of water on it, and cover it with a cover slip to hold it down.

them? One way is to compare the cells with the width of a piece of hair.

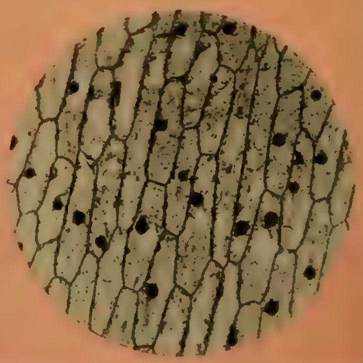
Put a piece of hair about an inch long on the slide with the onion skin. Then replace the cover slip. Move the slide around until you can see the hair on the onion cells. You may have to move the hair a few times before you can compare the size of an onion cell with the width of your hair. Make a chart like this of your findings:

AN ONION CELL FROM	HAIRWIDTHS LONG	HAIRWIDTHS WIDE
CENTER OF ONION		
MIDDLE OF ONION		
OUTSIDE OF ONION		
ROOT OF ONION		
LEAF OF ONION		

All living things are made of cells, but the cells differ in many ways. You might look for differences between the cells in onion skin and the cells inside a potato. With a toothpick, take out a pinhead-size bit of the potato's insides. Mash this on a slide, then add a drop of water and mash it more. Press a cover slip down on it. The thinner it is, the better you see it.

Do you see cells in a potato? Look at an apple, banana, grape, and tomato the same way. Make a sketch of each thing you see. What things have you discovered?

When you look through a microscope at a thin layer of onion, you may see a group of cells like this.



How Wide Is a Hair?

You can also use a hair to measure the cells you see in potato, apple, and so on. See how their size—in hairwidths—compares with the size of different onion cells. Then, to get a better idea of the size of a cell, you can figure out the width of a hair. Here's how to do it.

For 10 cents you can get a plastic ruler with the *metric* scale (centimeters) on one side and inches on the other. (About two and a half centimeters equals one inch.) A centimeter is divided into 10 *millimeters*. Cells and other tiny objects are usually measured in *microns*. A micron is one-thousandth of a millimeter.

Do you think you see as much as a millimeter in your home-made microscope? Put the ruler under the lens and find out. The area that you see through the lens of a microscope is called the *field*. How wide (in millimeters) is the field of your microscope? How many microns is that?

See if a hair is as wide as the field of your microscope. Compare the width of the hair with the width of the field you see. Can you figure out the width of your hair in microns? Once you know the width of the hair you can also figure out the size of cells and other things you see in the micro-world ■

TIPS ON SEEING CLEARLY WITH YOUR HOMEMADE MICROSCOPE

✓ For a very good light, put a small lamp with a shade and bulb (25-60 watts) flat on the table close to the microscope. Bright sunlight or a strong flashlight also works well.

✓ With the light shining full on the mirror (or aluminum foil), look through the lens. Tilt the mirror until you get all the light you can.

✓ Make sure that you put the slide on the microscope so that the object is over the hole in the spool. When it is in position, clip it firm.

✓ Does the closeness of your eye to the lens make a difference in what you see? Try different distances. If you wear glasses, you may see better through the microscope without them. Start with the lens almost touching the object. Move the lens up slowly until the object is clear. Use the nail or piece of wood to move the lens up and down ever so little. Sometimes your finger can give just the needed pressure. (If you move the lens up and down a lot, the strip loosens. To keep it near the object, put a strong elastic band around the other end of the microscope.)

✓ You can get rid of almost all **air bubbles** by removing the cover slip, then putting it on again and pressing firmly. If you see **shadows**, try adjusting the mirror, the light, and the lens until the shadows disappear. A blurred **image** usually means a dirty lens. Clean the lens with wet tissue on the end of a toothpick; dry it with dry tissue the same way.

Using This Issue...

(continued from page 2T)

time and Greenwich time—one hour difference in time being equivalent to 15 degrees of longitude ($\frac{1}{24}$ of 360 degrees). An error of 20 minutes ($\frac{1}{3}$ of an hour) would mean an error in longitude of $\frac{1}{3}$ x $\frac{1}{24}$ x 360, or 5°—about 300 miles at the equator!

PAGE 8 Horses

This Wall Chart shows some of the highlights of the evolution of horses, a classic example of evolution. However, you should point out to your pupils that the chart is a simplified view of a complex situation. Any such chart can sometimes give a misleading idea of how evolution works.

In the chart we have attempted to show that there was *not* a steady, gradual change from eohippus to *Equus* (modern horses). There is no straight lineage from early to modern horses. Instead, there were, at times, dozens of lines. After the Eocene, for example, horses developed three different kinds of feet. Each type was common in different groups of horses as late as the Pliocene, although only one type has survived today.

The story behind the name "eohippus" may interest your pupils. When fossil horses were first discovered in England, they were not recognized as ancestors of horses. Instead, they were thought to be like small, hooved animals called hyraxes. So the early horses were given the scientific name *Hyracotherium* (hie-*rack*-o-*thee*-ree-um), which means "the hyrax-like beast."

Later, early horses were discovered in North America and called *Eohippus* ("dawn horse"). For a time, it was thought that both *Eohippus* and *Hyracotherium* were related but distinct genera. Finally, in 1932, an adequate comparison of fossils showed that the two groups were so similar that they must be from the same genera. Under the rules for assigning scientific names, however, the first name assigned is usually the correct one, so today the scientific name for the genus of the first horses is *Hyracotherium* and eohippus is just a common name.

References

- The display shown on page 8T of the Oct. 18, 1965, issue of *N&S* shows the skulls and feet of some of the horses mentioned in the Wall Chart.
- *Horses,* by George Gaylord Simpson, Natural History Library, Doubleday & Company, Inc., New York, 1961, $1.45 (paper), describes what is known about modern horses and horse evolution. Simpson's discussion of patterns of evolution is particularly useful. The appendix lists museums which have displays of fossil horses.

PAGE 12 Bird Houses

Providing houses for birds is a conservation project that any individual or group can do. Although most of the projects described in the article are aimed at eastern bluebirds, there are many other hole-nesting species (including other species of bluebirds) whose abundance sometimes depends on the availability of nesting sites.

A common mistake in building and erecting bird houses is to forget that birds have territories. A male bluebird will not tolerate another within its territory, so it is silly to put up an "apartment house" for bluebirds, and individual bluebird houses should be at least 300 feet apart. Purple martins are the only species that nest in "apartment houses."

As the article points out, winter is the time to make bird houses ready for the spring, since the houses should be in place and weathered a bit before the birds begin nesting. Perhaps a local ornithologist can tell you what species need help in your area, and where your class might put up bird houses.

Cuddly Animals and Talking Atoms

(continued from page 1T)

lion as an "Evil Predator"?

We find it in books. Bambi's father is condemned because he seemingly deserts Bambi's mother.

We have all run across science stories in which an animal or plant that is merely reflecting evolutionary changes is given credit for thinking through its problems and meeting its environment head-on. If we absorb these stories, we find it difficult to understand the panorama of evolution. If we believe that there are such things as "good" and "evil" animals, we can never understand the ramifications of a food chain.

Teleology

The last type of personification, teleology, deals with the interpretation of natural phenomena in terms of purpose. Statements such as "the giraffe has a long neck so that he can eat leaves from trees" cause trouble. They not only are reversals of the basic cause and effect relationship, but also are presumptuous in that they assign a cause for which there is no evidence.

Here is another example: "Can you figure out why woodchucks don't change the color of their coats in the winter?"

If anyone asked me that question, I would say, "No, can you?"

We're not really sure why many things do what they do in nature. Maybe woodchucks don't change the color of their coats because they hibernate. Perhaps it is because they "just don't feel like it." Or it might be because a woodchuck with a white coat is not very "attractive" to other woodchucks.

Precise Language

Teachers pride themselves on the use of precise language. They may recoil in horror when someone says something like "I have a temperature." We all have temperatures; sometimes they are abnormally high or low.

Most teachers, however, are doing little about the basic problem of personification. If we do not do something about it, young people will continue to believe that Paramecia play games, that dogs can solve problems intellectually, and that kindly Mother Nature put our ears where they are so that we can wear sunglasses.

Youngsters have no trouble distinguishing between obvious fantasy and reality. They know that bears do not eat oatmeal and that geese do not lay golden eggs. They do have trouble, however, when we confront them with an idea that is close to reality. There is no argument against fantasy implied in the argument against the three types of personification, merely an objection to the mixing of fantasy with reality so that the observer cannot distinguish fact from fiction ■

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TEACHER'S EDITION

VOL. 3 NO. 10 / FEBRUARY 7, 1966 / SECTION 1 OF TWO SECTIONS

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What's in Our Name?

■ The words "nature" and "science" are among the most often used—and sometimes abused—words in our language. When we named our magazine we chose the words as a title for their sweep of meaning, as well as for the two very different ideas they denote.

The expressions "nature study," "nature walks," "nature writing," and so on were inherited from an earlier generation. In those days, the word "Nature" often implied a motherly deity who somehow tended the pleasanter things in the woods and fields. Today, we follow the scientists' less restricted, less personal concept of nature, an attitude that is more closely akin to the seventeenth century English philosopher Thomas Hobbes than to Disney—"...such facts or effects as have no dependence on man's will," as Hobbes wrote. In short, the stars and electromagnetic energy we receive from them are as much a part of nature as the water lily and shady glens which Edward MacDowell set to music in his "Woodland Sketches."

Science, on the other hand, is a way of inquiring into nature—its qualitative and quantitative aspects—by systematically classifying observed phenomena and by bringing them together as concepts, or general truths. But the truths of science are not ends in themselves. Today's truths serve simply as working hypotheses among which tomorrow's truths may be built.

It is that spirit of inquiry (science) and that realm of the universe (nature) which we hoped to convey when we named our magazine *Nature and Science.*—THE EDITORS

NSTA "How to..." Series

■ If your problem is how to: *Care for Living Things in the Classroom; Teach Science through Field Studies; Record and Use Data; Utilize the Services of a Science Consultant,* you will find many nuggets of knowledge in a new "How to . . ." series of pamphlets issued by the National Science Teachers Association.

The above titles are the first four off the press and are available from NSTA (1201 Sixteenth Street, N.W., Washington, D.C. 20036) for 35 cents each with discounts of 10 per cent for 2-9 copies, 20 per cent for 10 or more.

The pamphlets range from 6 to 16 pages 8½ by 11 inches in size and are prepared by teachers of education at various universities.

Of the first four, *Care for Living Things in the Classroom* (16 pp.) is the meatiest, offering down-to-earth suggestions about caring for a variety of mammals, fishes, amphibians, reptiles, and plants. The booklets stress the science in their out-of-class and in-class activities and point out the dangers of some class projects—however well intended—decaying into a random romp through the zoo ■

nature and science

IN THIS ISSUE

(For classroom use of articles preceded by ●, see pages 2T, 3T, 4T.)

● **What's in a Pattern?**
Creating their own moiré patterns can awaken your pupils to patterns in the world around us and help them understand some ways in which scientists use patterns.

● **Growing Your Own Changes**
Left to themselves, some substances will rust, mold, or simply decay. Your pupils can investigate these changes and find out what conditions speed them up or slow them down.

How Scientists Use Photography
Pictures illustrate the use of photography to "stop" action, "see inside" things, detect faint light, and make pictures with heat. Two projects your pupils can try.

● **Symbol of the Wild**
An account of the author's experiences studying one of North America's rarest mammals.

● **Around the World with Captain Cook—Part 2**
Completing his voyage, the explorer charted previously unknown coasts, discovered the kangaroo and Maoris, and lopped off a slice of the mythical Great Southern Continent.

Brain-Booster Contest

IN THE NEXT ISSUE

A Special-Topic Issue: Inside animal populations...The mysteries of population cycles...A WALL CHART of factors that control animal numbers...How your pupils can investigate populations of insects and other small animals . . . Too many people?

USING THIS ISSUE OF NATURE AND SCIENCE IN YOUR CLASSROOM

PAGE 2 Moiré Patterns

Moiré patterns are fascinating. Half the fun of them is in making your own and watching the patterns change as you move one grid over another one.

After playing with moiré patterns for a while, your pupils will probably jump at the chance to make some grids of their own and see the patterns projected with an overhead projector.

Let them use their imagination in making their own line patterns, even if some of the patterns don't "work." Those that don't work can then be discussed—why don't they work? Compare them with the designs shown in the student's edition. Carefully examine the spacing of the lines in all the patterns. A compass and ballpoint pen can be used to make wavy patterns. Rulers and ballpoints with ink of different colors can be used to make straight-line patterns. Have some of your pupils make straight-line patterns that are not uniformly spaced—for example, a dozen or so lines ¼" apart, then a dozen or more lines ⅛" apart, and another dozen or so 1/16" apart. Have them make two such grids, then move one over the other at various angles.

Encourage children to use different colors—red on black, red on blue, yellow on brown, orange on green, and so on. Nearly everything they draw will produce interesting results.

Large art supply shops stock transparent, wax-backed sheets that have geometric designs printed on them—dot patterns, line patterns, and zig-zag figures. These sheets are handy for making moiré patterns. Trade names include Zip-A-Tone and Contact.

PAGE 6 Growing Changes

This Science Workshop introduces your pupils to some of the relationships between microbial growth and food and garbage. Some things will change faster than others. Rich foods and moist materials may change quickly. Even things like tobacco and cloth may decompose, but it may take several weeks. The rate of change depends on many factors, as the children will soon realize (e.g., what is put in the box, amount of moisture, temperature, etc.).

Although the molds and bacteria that will grow are harmless, there may be some unpleasant odors. Keep all containers covered. If a growth of mold or bacteria is touched, hands should be washed with soap.

Discuss with your class the "puzzler" on page 7. They will probably detect the flaws in the boy's investigation. He had not proved that melting was the cause of the wax puddle around the first crayon because he didn't duplicate the conditions in which the original crayon "melted." For example, the original crayon was left for several days; the others for only a few hours. The original crayon was neither in a refrigerator nor above a radiator.

See also "Making a Mold Garden," *N&S*, Jan. 24, 1964, and "The Mold That Didn't Belong," *N&S*, May 1, 1964. Both of these articles are in *N&S* Resource Study Unit #103, *Investigations with Plants.*

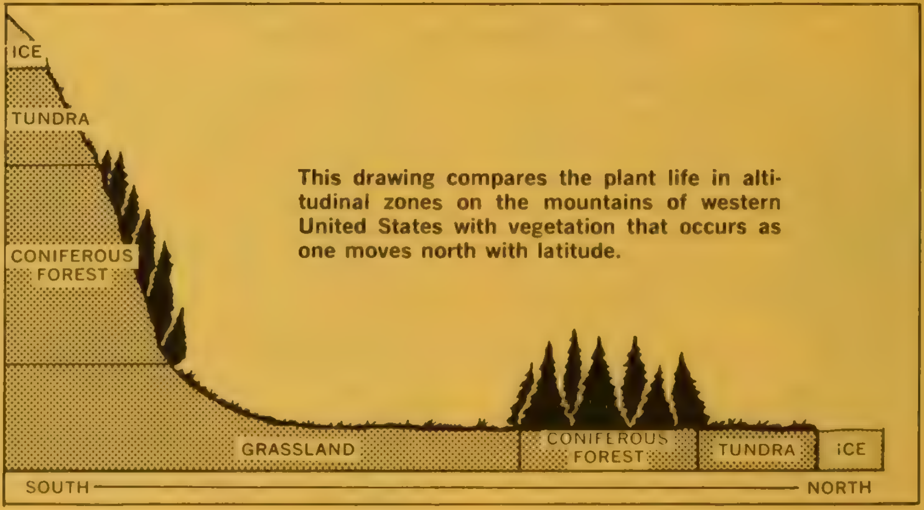
"Growing Your Own Changes" was adapted from a unit being developed by the Elementary Science Study of Educational Services Incorporated. The unit, called *Changes*, is scheduled for publication as a trial teaching edition in the late spring. Meantime, for test teaching in elementary school classrooms, an interim mimeographed guide may be obtained by writing to Dr. Lynn Sagan, Educational Services Incorporated, Box 415, Watertown, Mass. 02172.

PAGE 10 Symbol of the Wild

The pine marten is adapted to the environment of wild, northern coniferous forests. Martens cannot survive when these forests are cut or "civilized."

In the east, martens formerly lived as far south as Virginia. In the west, martens still live in mountainous parts of the southwest. Your class may wonder: How can an animal of the north woods survive so far south? The answer lies in the altitude of the mountains. As you climb a mountain, the air becomes thinner and colder. Mountains usually get more precipitation than nearby lowlands, especially on their windward sides. Because of these

(Continued on page 3T)



This drawing compares the plant life in altitudinal zones on the mountains of western United States with vegetation that occurs as one moves north with latitude.

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nature and science

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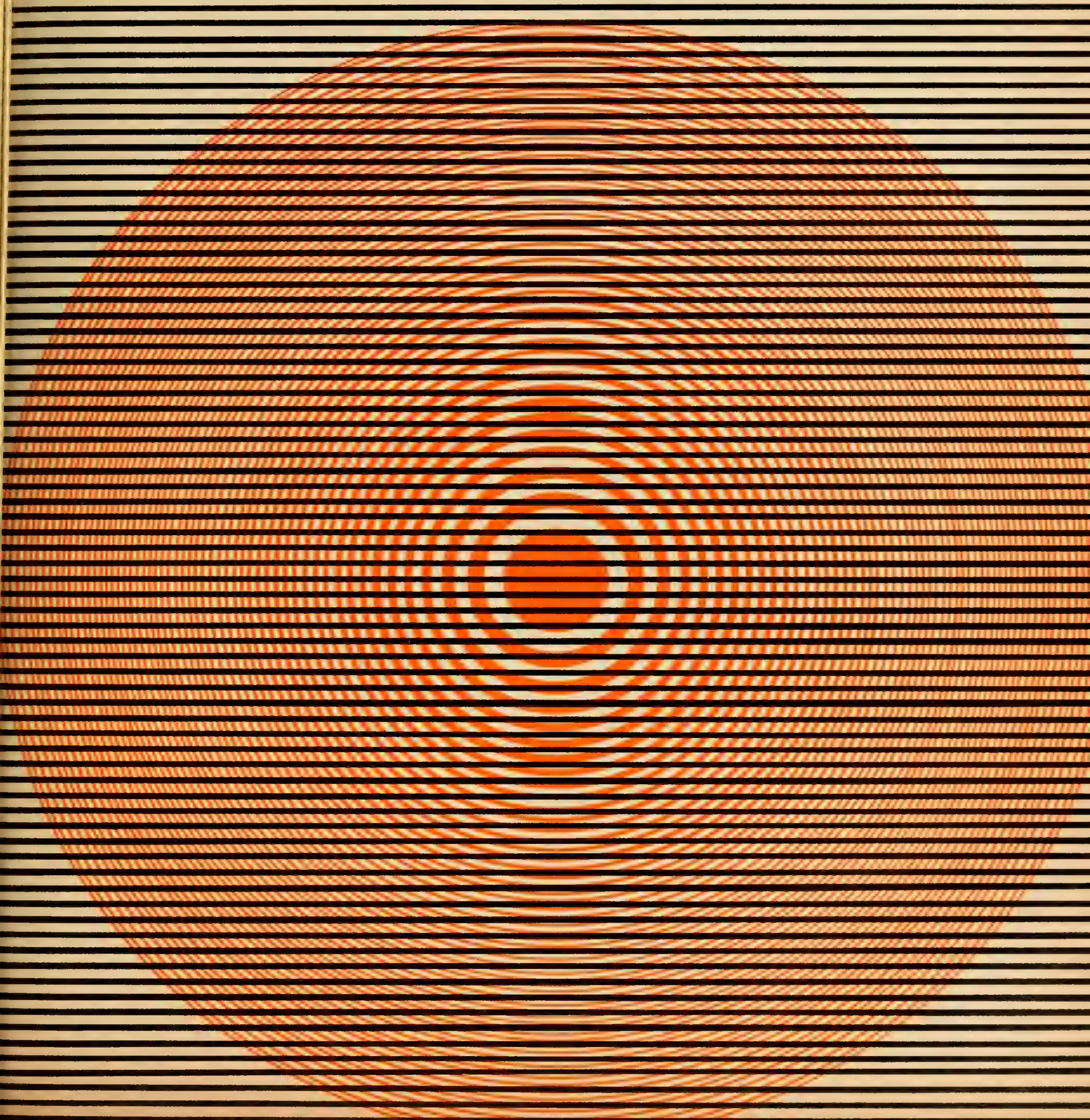
Photographs reveal many things that our eyes could not otherwise detect.

see page 8

HOW SCIENTISTS USE PHOTOGRAPHY

MAKE YOUR OWN DAZZLING DESIGNS see page 2



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WHAT'S

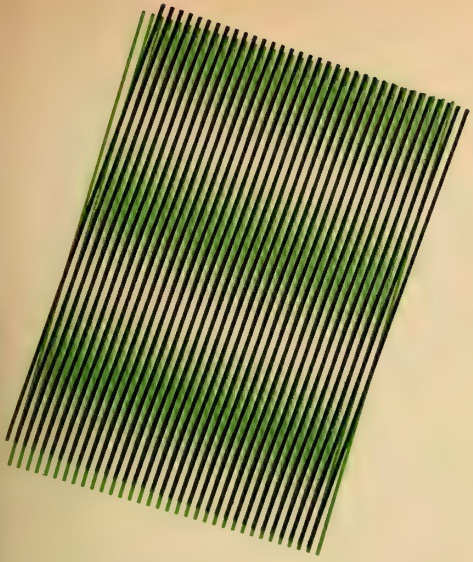
by Colin A. Ronan

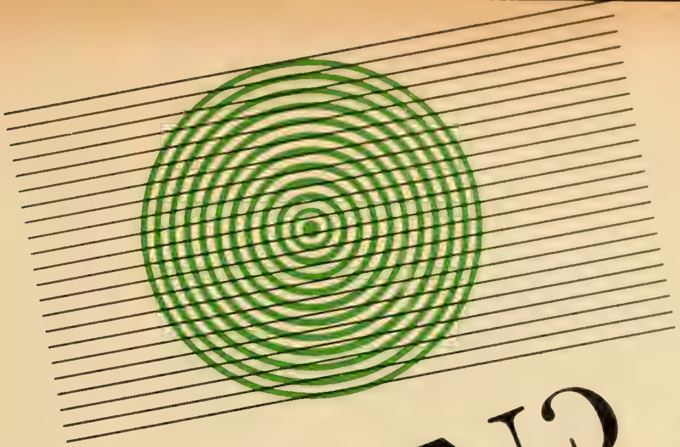
Fences, railway ties, curtains, combs, and dozens of other everyday things produce perfect patterns as plentiful and pleasing as peanuts.

■ All around us there are patterns. The lines of printing c this page form patterns. If there is a carpet on the floo perhaps it, too, has patterns. Or if sunlight is shinir through the window curtains in a certain way, you may l able to see many different patterns. When you go outsic you can see a pattern formed by the posts of a fence, or tl ties of a railroad track. There are patterns everywhere.

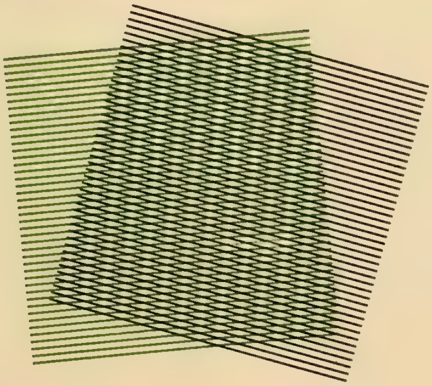
What Makes Patterns?

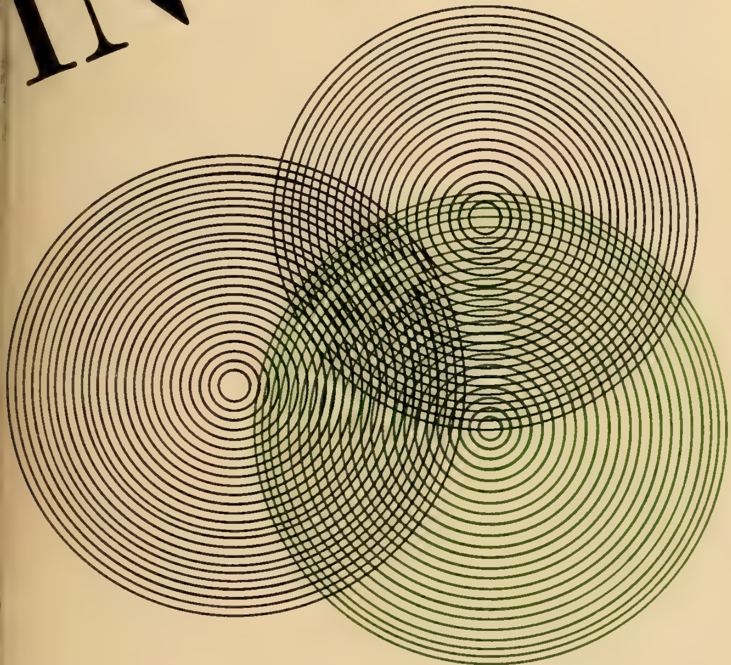
One way to make patterns is to space things at regul

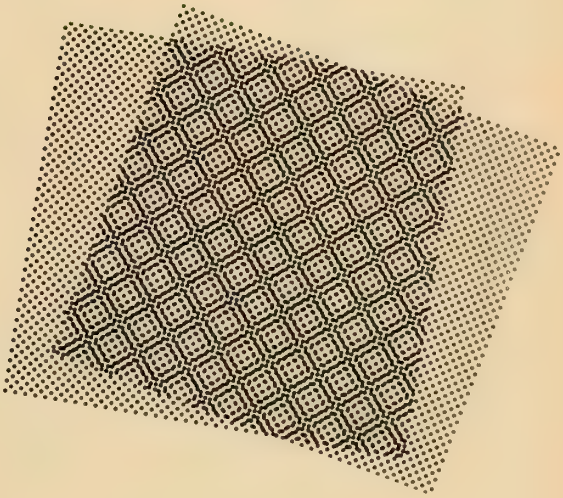




IN A PATTERN?



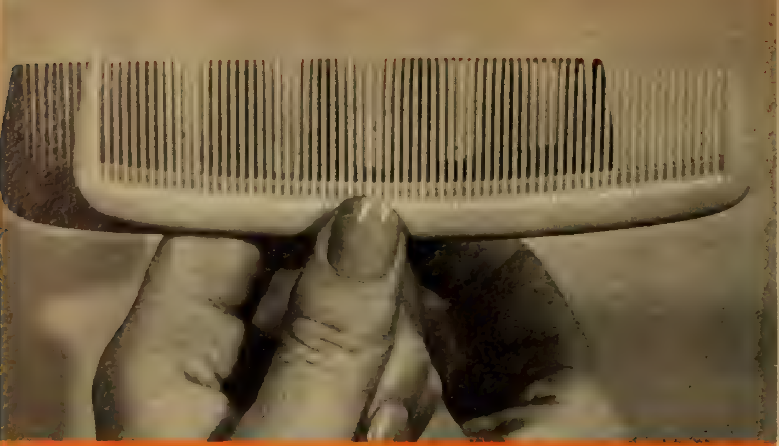




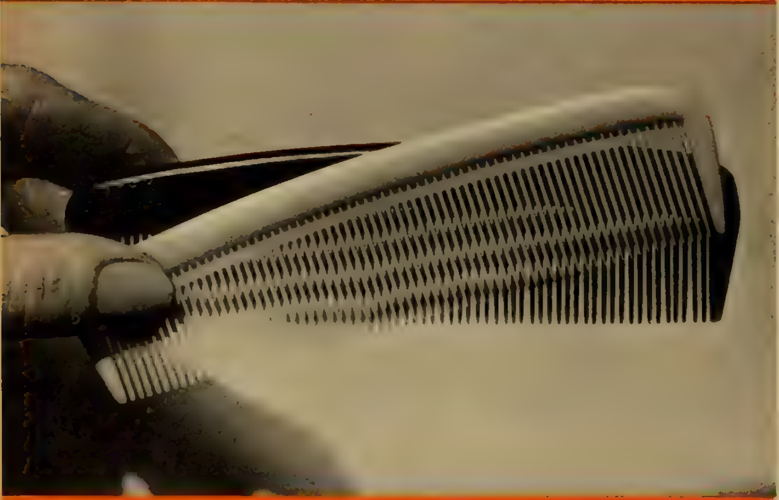
distances from each other. The kind of pattern you see depends on the spacing, or *frequency,* of the objects. You can think of frequency as so many things per inch, per foot, or per yard. For instance, the frequency of lines on this page is 5½ lines per inch. The frequency of stairway railings is often about two per foot. You can change the frequency of a pattern by mixing it with another pattern of the same kind. Mixing patterns can be great fun and often produces new patterns that are more interesting than the separate ones.

One of the easiest ways to mix patterns is to use two ordinary hair combs with all the teeth evenly spaced. Take one comb—a pocket comb will do—and count the teeth. If the teeth are evenly spaced, they will have a frequency of about 18 to 11 per inch. Now take a second and similar comb with teeth at the same frequency. Place one comb over the other, getting them as exactly in line as you can, then hold them up to the light. Next move one comb *slowly* across the other from left to right. You will see a changing

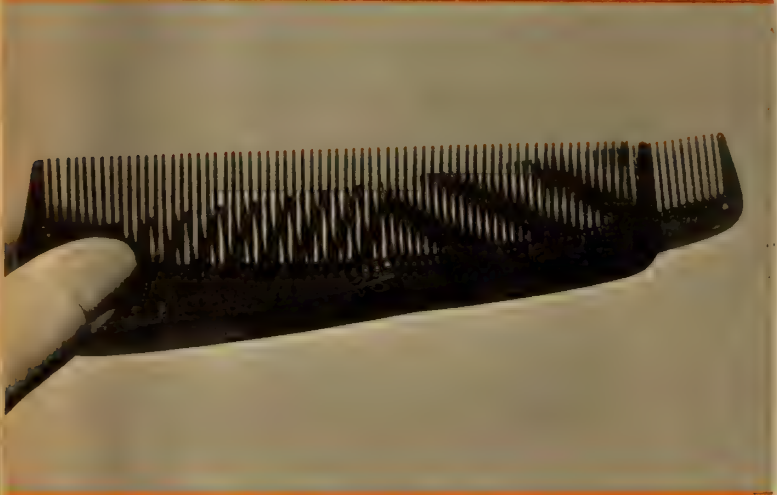
(Continued on the next page)



1. When two combs are held slightly apart (about 6 inches here), the gaps between teeth of the nearer comb appear to be wider than tooth gaps in the more distant comb.



2. Two similar combs held together, but at an angle, produce an interesting moiré pattern. The wavy lines show that the comb teeth are not exactly evenly spaced. Scientists use moiré patterns to find flaws in materials.



3. One comb with all small teeth and one with small and big teeth (front comb) make a still different pattern.

pattern. As you move one comb across the other, a black patch seems to travel from one end to the other. Study this moving black patch carefully. What causes it?

Next, hold one comb away from you at arm's length. With the other hand, line up the second comb with the first so that it is about 12 inches closer to you than the first one. The teeth and spaces of the close comb will not look as if they are the same distance apart as the teeth of the far comb. Their frequency will seem to be different. You will get some of the teeth of the near comb in step with some of the gaps between the teeth of the far comb, but not with all of them. You will see what looks like a pattern of much thicker teeth, separated by equally large gaps. You are seeing a *magnified* pattern of the combs (*see Photo 1*).

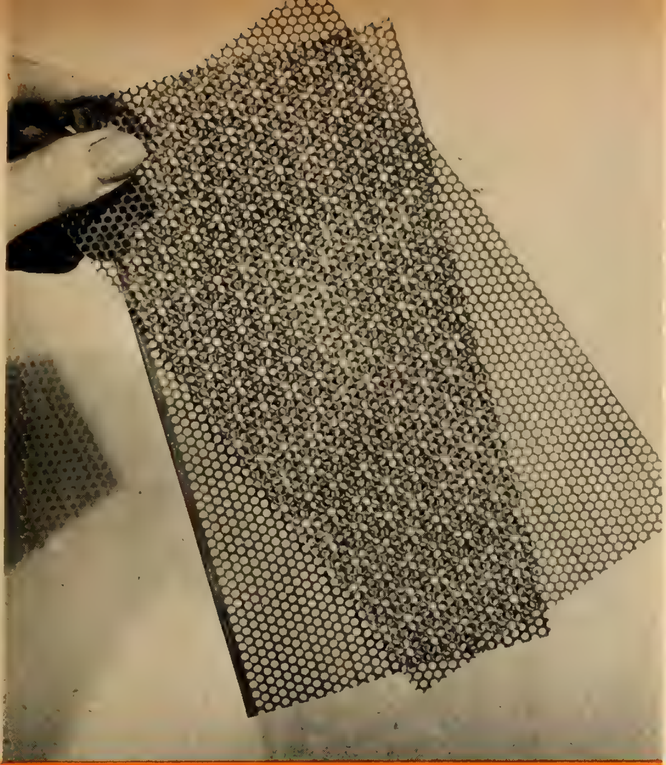
Now put the combs close together again, but this time tilt one of them a little (*Photo 2*). You will notice that the lines of the pattern are tilted, but they are not tilted as much as the combs. If you measured the angle of the tilt, you would find it to be only half as much as the angle formed by the two combs. Look carefully at the way the teeth cross. Can you figure out why the angles are different? (One dark comb and one light one will help to make this easier to see.)

If you move one comb across the other, you will find that the lines forming the horizontal pattern stay the same distance apart, but move up and down. Now change the angle between the combs by making the angle bigger. What do you see? Do the horizontal lines move closer together or farther apart? Do the lines themselves become thicker or thinner? When you form a cross with the combs by holding one at right-angles across the other, what kind of pattern do you see? See how many different patterns you can make by replacing one of the combs with a comb that has big teeth at one end and small teeth at the other end (*see Photo 3*).

Patterns All Around You

You can make interesting patterns with two pieces of punched metal sheets (*see Photo 4*), or pieces of transparent art paper with an arrangement of evenly spaced dots. You can often see patterns in the everyday world around you. Have you ever noticed the patterns formed by a fine-mesh curtain moving back and forth across a window screen? Or the patterns formed when you are driving past two fences, one behind the other. As you are driving along in a car you can see many such patterns if you look for them.

Nearly 150 years ago a new kind of silk was made. It had patterns like the ones you made with your combs. The silk was woven with tiny lines or ribs running along it, and then it was folded over so that the ribs were nearly in line with each other. The resulting patterns made the silk shimmer in the light, just as water in a pool does. This is



4. When held at an angle of 20°, these two metal sheets punched with round holes produce a flower-like pattern.

why it was called "watered silk," or *moiré* silk, from the French word meaning "watered." Patterns like those you have been making are called *moiré patterns.*

Scientists use moiré patterns in many ways. Because a moiré pattern can magnify the original pattern of an object —as happened with your two combs when you held them apart—it can be used to show how atoms are arranged inside a substance. For instance, by making a tiny crystal grow on top of another crystal, scientists can get a moiré pattern which shows how the atoms in both crystals are arranged. This is important for finding out how atoms make up complicated substances (*see Photo 5*).

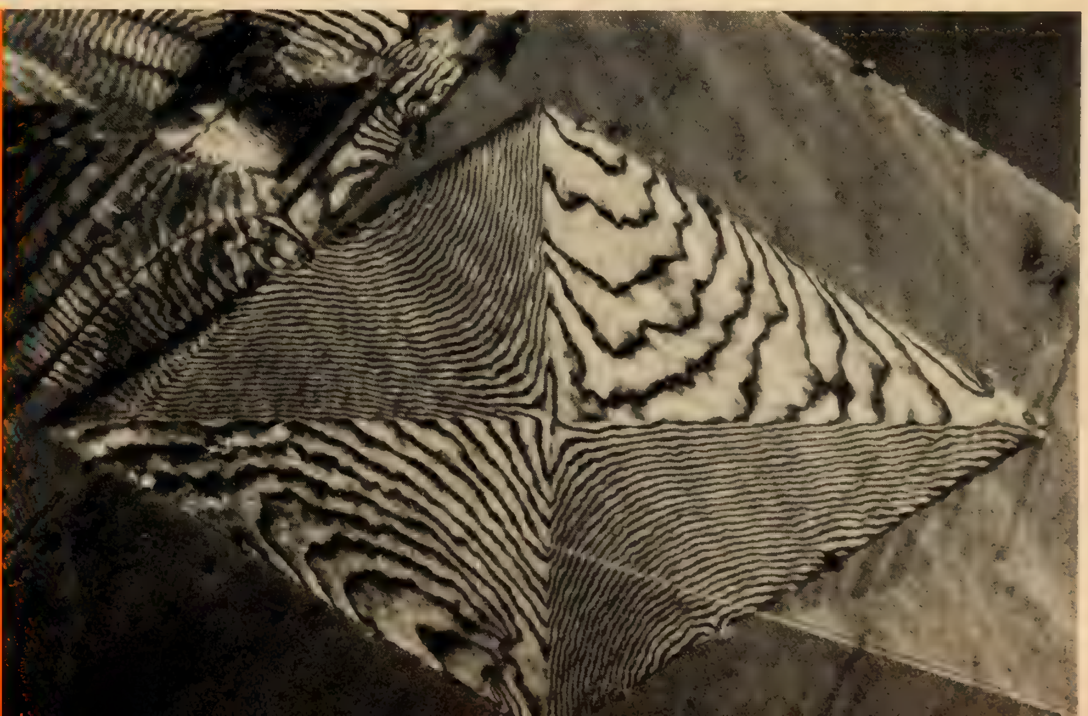
Scientists can also use moiré patterns to find out many things about substances and how they dissolve in a liquid. Imagine a narrow fish tank filled with water. The front glass surface of the tank has a straight line pattern, or *grid,* stuck to it, as does the rear surface, but one of the grids is tilted slightly. As you look through the tank, you see a pattern something like that shown by the top left moiré pattern on page 3. Now, if you hold a cube of sugar in the tank, the sugar will dissolve. As it does, it breaks up the moiré pattern. By watching such changing moiré patterns, scientists can tell how quickly or slowly different things dissolve and how long it takes them to *diffuse,* or spread through the liquid.

Waves crossing each other at the entrance to a harbor make many patterns. By examining the patterns through ruled grids, engineers have been able to design breakwaters that work very well.

For some time now, artists have been drawing and painting patterns of this kind. They use circles and other curves as well as straight lines, and make some striking patterns, as shown on pages 2 and 3. Since the patterns can trick the eye, the pictures are called *optical* art, *op* art for short.

Many moiré patterns produce *after-images*. To find out which of the patterns shown in this article produce an after-image, stare at the pattern about 20 seconds, then look at a blank sheet of paper. If an after-image appears, close your eyes for two or three seconds, then open them again. How many times can you bring the after-image back? You can spend many pleasant hours making and experimenting with moiré patterns of your own ■

5. Growing one crystal on top of another one makes moiré patterns that show the arrangement of atoms in the crystals. This photo shows the pattern made by a small crystal of polyethylene grown on top of a larger crystal of the same substance.



SCIENCE WORKSHOP

Growing Your Own Changes

by Lynn Sagan

Gather some jars and plastic boxes, put in some food, liquids, and other things. Let the stuff stand for a few days. Then see if you can explain the amazing changes you'll discover.

■ *"Time changes all things"* is an old saying. Do you think it is true? Can you think of anything that *never* changes? What things rust or get moldy? What things decay all by themselves?

To investigate these ideas, all you need are some common items from the kitchen—about 15 containers, such as jars or plastic boxes, and some Saran wrap or freezer bags *(see photo on next page)*. Think of what things you could put in the containers that will change *if left to themselves*. What things will change if left in the jar *with just a little water?*

What will happen to damp pipe tobacco? What about wet paper? Cough medicine? A slice of tomato? Milk? You might want to predict when and how your things will change. Will they mold; will they rust; will they change color?

Testing Your Ideas

Make a list of the things you thought of, then test your ideas. First, collect all of the things you put on your list. Be sure that some of them are liquids. Put them in your jars and bags. (Do you think it is wise to put a lot of things together? How will you be able to tell which has changed?) Put labels on the containers that tell what you put inside. (When the things change, you may not recognize them.) Cover the containers with Saran wrap or in some other way so that you can still see into them. Leave your containers lined up along a window sill, on a table, or in any other place where they are easily observed.

Some changes are gradual. Plan to take a look at your boxes regularly each day. Take notes on what you see, day by day.

After a few days, you may see mold on some things. Which things get moldy first? If you have a microscope you might take a very little bit of fuzzy mold and examine it. Is anything growing in the liquids? You might examine drops of liquid from the jars under the microscope, too.

The growths you are observing begin because tiny, seed-like *spores* which float in the air land in the container. Mold spores begin to grow into mold; spores from bacteria take in water and divide to form more bacteria. (Bacteria also reproduce by dividing in half.) There are thousands of different airborne spores landing on our things all of the time. However, a spore begins to grow only if conditions are just right for it. This is the reason that you often find green mold on the outside of cantaloupe and oranges but hardly ever on the outside of potatoes or avocadoes.

Check your containers for several weeks or longer. Many of the changes are gradual. Some of the less dra-

These boys put food inside dishes which were then covered and sealed. They are looking at molds that grew on the food.

A PUZZLER

A boy put a crayon in a box. After a few days there was sort of a wax puddle around his crayon. He thought it was due to melting. To attempt to prove this he took two similar crayons and put one in the refrigerator. He put the other on a shelf above the radiator.

In a few hours the one above the radiator looked like his original. The one in the refrigerator hadn't changed at all. He had caused a change in the crayon like the one which he had originally observed. Had he proved for sure that "melting" was the cause of the wax puddle?

matic changes in your container are probably not due to the growth of molds or bacteria. Some may be due to rusting, for example. Can you figure out what kind of changes you have in each of your boxes?

Make lists of the ways in which things have changed. Which have molded? Rusted? Changed in other ways? Which have not changed at all? Are these lists just as you predicted?

Comparing Wet and Dry Things

Look over your lists and notice what happened to different kinds of food. Does wet food change faster than dry food? Here are a couple of ways you can find out.

One way is to place two similar foods, one wet and one dry, in pairs of containers. Use four pairs of plastic sandwich boxes or similar containers. Mark one of each pair of boxes "wet" and the other "dry." Put the same things in each pair of boxes. For example, you might put a cookie in each box of the first pair, a spoonful of dry powdered milk in the second pair, and dried apricots in the third pair. Leave one box of each pair dry and add some water to all of the other boxes. Make sure that all boxes are kept at the same temperature. After the second day, look for differences in the boxes. Must the differences be due to water?

You might also take about eight boxes and line them up next to each other, numbering them from "1" to "8" Place a similar cookie, cracker, or piece of bread in each box. Leave the first box dry. Add water to each of the other boxes in varying amounts. Watch your boxes over the next few days. What happens?

Perhaps you can draw some conclusions from your findings. Does wet food change faster than dry food? Why? ■

MORE PUZZLING QUESTIONS

- Do the same things change in the same way?
- Does mold grow better in the light?
- Do things change more slowly in the cold?
- Do molds grow in liquids?

If you think you can answer these questions (or other questions of your own) on the basis of your experiments, write to me and tell me what you have found.

Write to: *Dr. Lynn Sagan*
c/o Elementary Science Study
108 Water Street
Watertown, Massachusetts

Wylers
KEEP IN COOL DRY PLACE

You can use containers such as freezer bags, glass jars, and plastic boxes for your investigations into how things change.

If the containers do not have covers, use Saran wrap or some other covering that you can see through.

HOW SCIENTISTS USE PHOTOGRAPHY

■ Scientists use many kinds of tools in their exploration of the unknown. One such tool is mathematics. No one can become a good scientist without knowing how to use it. Another important tool is photography. Scientists can see things in photographs that their eyes might miss. Photographs can record light that is too faint for our eyes to see. Photographic film can detect rays that are invisible to us. And automatic cameras can be sent where it is dangerous—or impossible—for humans to go.

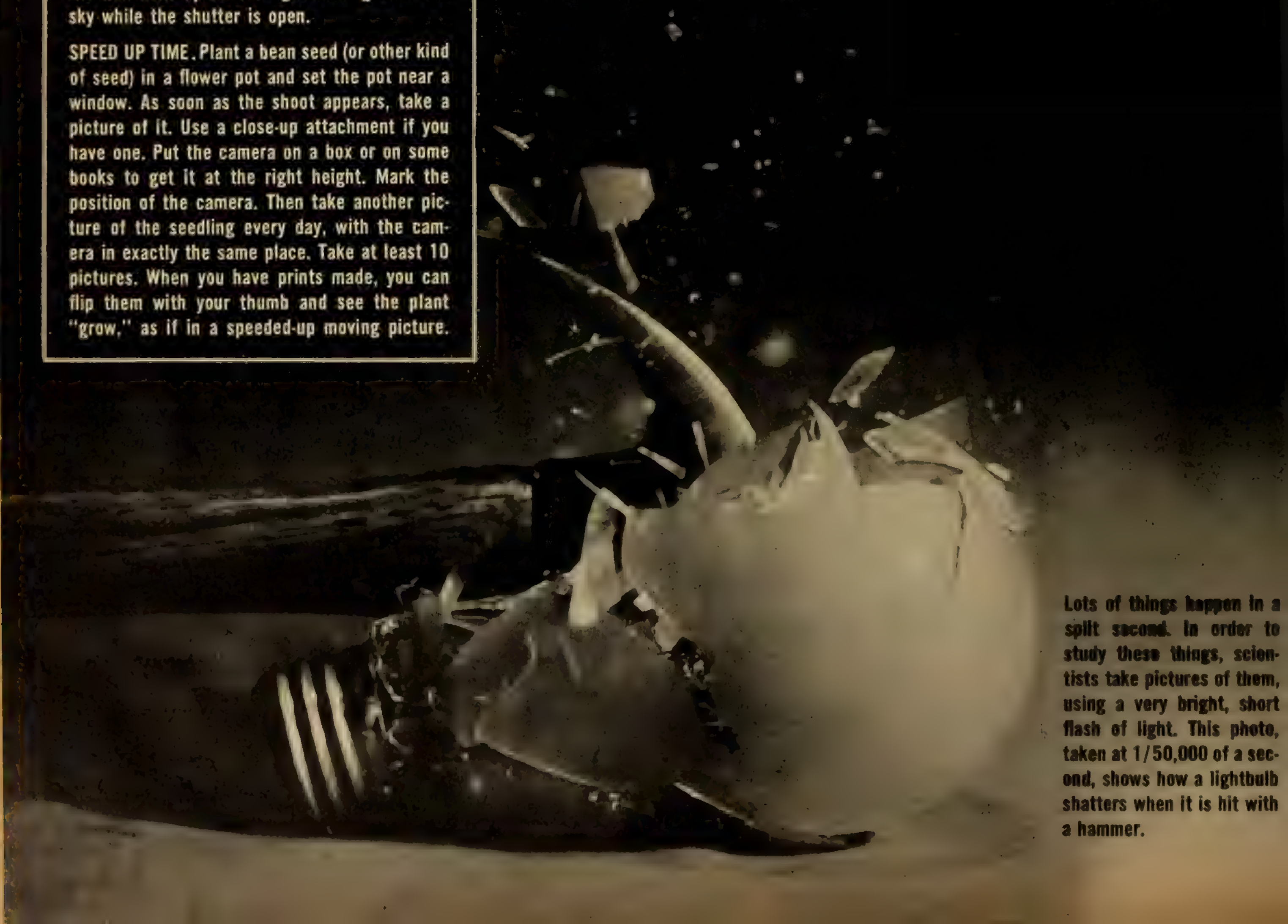
The pictures on these pages show a few of the ways in which scientists use photography. The projects (left) tell how you can photograph lightning and growing plants ■

PROJECTS

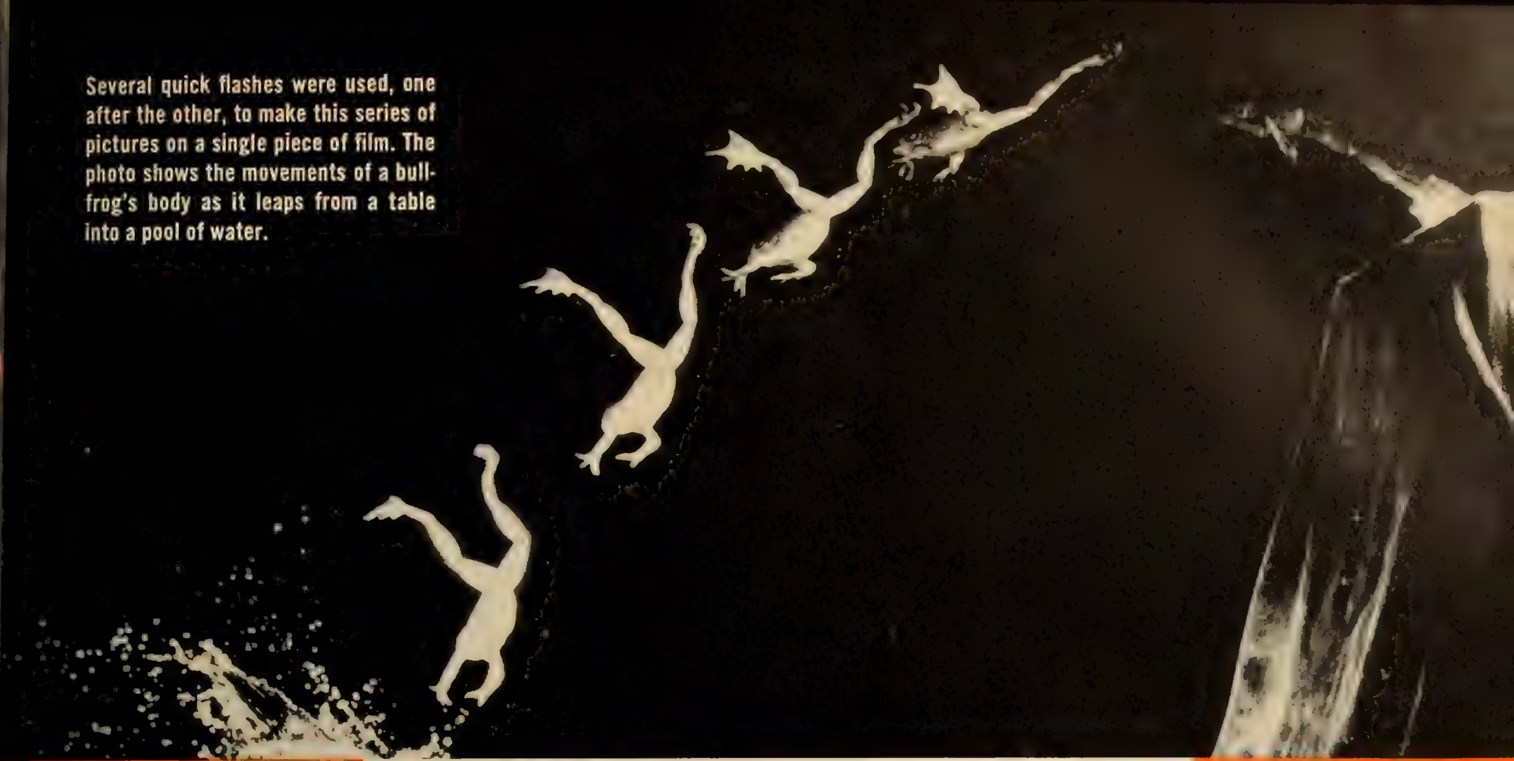
TAKE A PICTURE OF LIGHTNING. During a thunderstorm at night, put your camera on a window sill so that it points toward the part of the sky where you see the most lightning. Set the camera for time exposure. Open the shutter and wait. When you see a lightning flash in the direction that the camera is aimed, close the shutter. Then wind the film and try again.

You will find that the longer you have to wait for a flash, the lighter the sky will look in the picture. It may even look as light as day, since the film adds up all the light coming from the sky while the shutter is open.

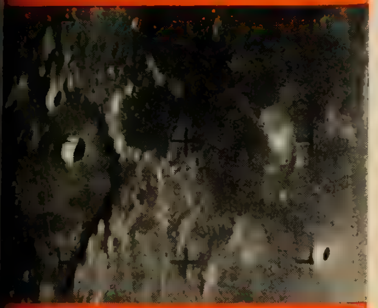
SPEED UP TIME. Plant a bean seed (or other kind of seed) in a flower pot and set the pot near a window. As soon as the shoot appears, take a picture of it. Use a close-up attachment if you have one. Put the camera on a box or on some books to get it at the right height. Mark the position of the camera. Then take another picture of the seedling every day, with the camera in exactly the same place. Take at least 10 pictures. When you have prints made, you can flip them with your thumb and see the plant "grow," as if in a speeded-up moving picture.



Lots of things happen in a split second. In order to study these things, scientists take pictures of them, using a very bright, short flash of light. This photo, taken at 1/50,000 of a second, shows how a lightbulb shatters when it is hit with a hammer.

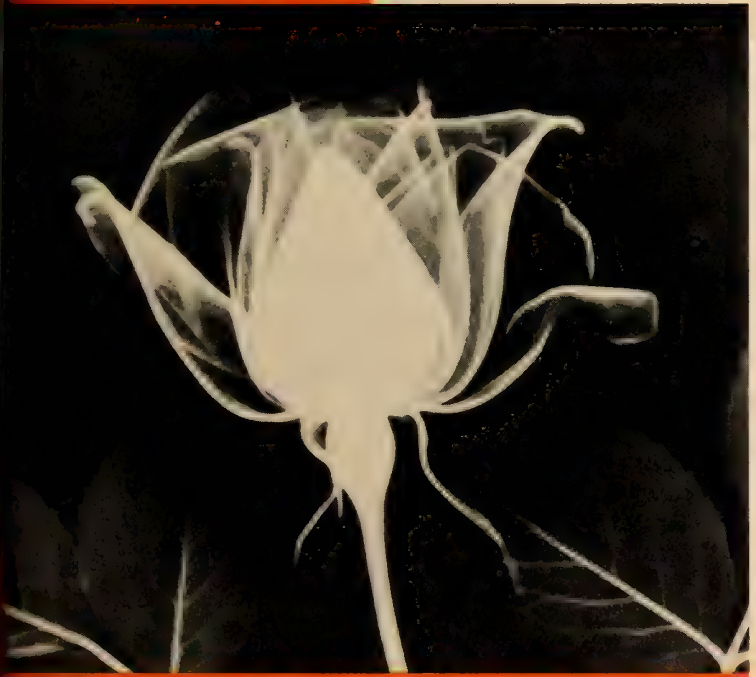


Several quick flashes were used, one after the other, to make this series of pictures on a single piece of film. The photo shows the movements of a bullfrog's body as it leaps from a table into a pool of water.

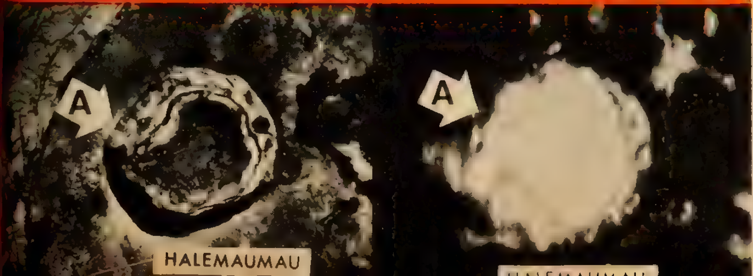


This is a picture of the surface of the moon, taken from 470 miles away by an automatic camera in the Ranger VII spacecraft. Several camera-carrying spacecraft have taken photos of the moon. The pictures they send back to earth help scientists plan man's landing on the moon.

In the center of this photo is the Horsehead Nebula in the constellation Orion. The Horsehead Nebula is a vast, dark cloud of dust and gas. In order to study it, astronomers make a long time exposure so light from the bright gases behind the nebula silhouettes it. Such photos must be taken through a telescope that tracks the objects, which appear to move as the earth rotates. If the telescope did not follow the apparent motion of the nebula, the light would be blurred on the photograph, and the outline of the dark nebula could not be seen.



X-ray photos enable scientists to "see through" the petals of a rose and other materials that they can not see through with ordinary light. X-rays are invisible to human eyes, but can be detected on special film. These rays pass through skin, muscle, and even thin metal, but they are stopped by such things as bone, teeth, and dental fillings. X-ray photos are often used to study the bones and organs within the bodies of animals and the insides of such things as machine and engines.



Photos can be made with kinds of light that we cannot see. Some kinds of film detect the infrared rays that come from all hot objects. The photo at left, taken with regular film, shows an aerial view of a volcano in Hawaii. The photo on the right shows the same scene taken with infrared film. The light areas are the hottest. Photos like these help geologists study the behavior of volcanoes.

Symbol of the Wild

by **Darrell L. Coe**

I spent two winters in the Rocky Mountain wilderness, getting to know one of North America's rarest mammals.

This pine marten was photographed just after it caught a red squirrel. Martens also eat mice and snowshoe hares which they catch on the ground. Martens are related to weasels and mink and are about the size of house cats.

■ The sky was blue and the air crisp as I stepped from the cabin door that December morning. The long, quiet winter of the northern Rockies had set in and three feet of snow covered the forest floor. I was spending the winter high in the mountains of northwestern Wyoming and every day brought something new and interesting. My next surprise was only a moment away.

Turning to reach for a pair of snowshoes hanging by the cabin door, I suddenly saw an animal staring at me. It was perched on the lowest limb of a lodgepole pine, less than 20 feet away. It watched me for almost a minute; then darted into the woods and was gone.

My curious visitor was a *pine marten*, one of the rarest mammals in the mountains *(see photo above)*. I had seen marten tracks in the snow many times and, once or twice, had caught a fleeting glimpse as one scurried through the trees. But this was my first opportunity to see a marten at close range.

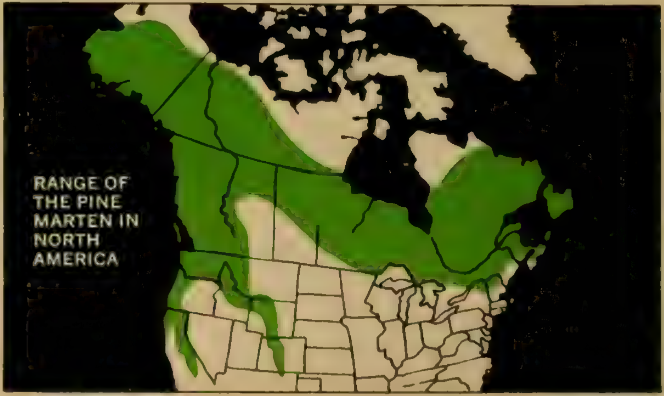
During that winter a number of martens came near my cabin. As I learned more about these animals, I found them to be as interesting as they are beautiful.

From Limb to Limb

The pine marten (sometimes called the *American sable*) belongs to the weasel family. It lives in the spruce-fir and pine forests in mountainous areas of the United States and over much of Canada (*see map*). An adult male measures about 25 inches from its nose to the end of its bushy tail. It weighs from two to four pounds. The female is slightly smaller. Like the Canada lynx and the snowshoe hare, the marten's feet are unusually large when compared with its body. The big feet of these mammals enable them to travel over snow without sinking in much.

Martens scurry up and down trees like squirrels. They leap from tree to tree, often jumping four or five feet from one limb to another. When a marten comes down a tree, it may climb down the trunk head first or simply "bail out"—jumping with tail and all four legs spread out.

One afternoon, I sat outside my cabin watching a marten in a tree just outside the window. A gray jay flew into the clearing and landed on the ground below. The marten



watched from above as the bird pecked at food in the snow. Suddenly the marten jumped from 15 feet up in the tree. The gray jay flew off an instant before the marten landed on the exact spot where the bird had been standing.

Martens do not spend all their time hunting in trees. In fact, they travel and hunt on the ground more often than in trees. A biologist in Minnesota once followed two martens for more than 17 miles. In that distance neither animal climbed a tree.

The Night Visitors

Martens may be active during both night and day. I learned something about their nighttime activity when my cabin became a favorite spot for the martens from the surrounding countryside. Once in a while my sleep was interrupted when a lone marten found his way under the roof and scampered over the attic floor. Later, the attic seemed to be a sort of marten meeting place. Screams and snarls came from directly over my bed every night. The climax of these visits came one night late in January.

I had been sleeping for several hours when the stillness was shattered by a crash. Climbing out of bed, I made my way to the kitchen where the disturbance seemed to be. I opened the pantry door and found the floor covered with cans and boxes. A screen covering a vent from the ceiling to the attic was torn away. In the middle of the confusion, crouched between two cans of pork and beans, was a pine marten.

The author's adventures with martens began when he was a park ranger in Yellowstone National Park. This photo shows sled dogs pulling Darrell Coe through part of Mt. McKinley National Park in Alaska. Mr. Coe is now ranger-in-charge at Katmai National Monument, in southwestern Alaska.

PROJECT

Try to find out what kinds of mammals, birds, and other animals have disappeared from your area because of changes made by man. Is anything being done to stop the disappearance of wild animals from your area? Have changes made by man helped some kinds of wild animals to increase in number? You may find answers to these questions in books or magazines in your library, or from your state conservation department (in the state capital).

The marten had jumped down from the attic after somehow pulling away the heavy screen from the vent. In jumping, it had landed on a shelf piled high with the winter's provisions, setting off an avalanche of groceries. After a short chase I caught the marten in a cardboard box, stepped out the door, and released it in the snow.

The temperature that night was 25 degrees below zero and I was happy to climb back into my warm bed. No sooner had I relaxed than a loud crash rocked the cabin.

In less than a minute the marten had re-entered the attic, crawled through the vent, and jumped into the pantry, knocking over more cans and breaking a bottle of syrup. After removing the marten for the second time, I firmly decided to make the cabin "marten proof" before another day passed.

By the time I had cleaned up the mess in the pantry the following day my annoyance at martens had eased. After all, their presence had at least one positive effect. The deer mice that were so abundant in and around the cabin the preceding autumn had disappeared soon after the martens moved in.

This was no coincidence. Studies have shown that mice are an important food for the pine marten. Martens also eat squirrels, insects, berries, and birds. During the winter months when snow is piled high snowshoe hares are sometimes eaten.

Without Wilderness . . .

I feel lucky to have seen so many martens during my days—and nights—in the woods. Even in areas where mar-

(Continued on the next page)

Symbol of the Wild (continued)

tens are plentiful, sightings of these beautiful mammals are rare. There was a fur trapper in Maine who caught as many as 11 martens in a single day, but saw only three running free in his lifetime.

Marten fur is valuable and the animals are easy to trap. Millions of martens have been caught by trappers. However, this is not the main reason for their disappearance from many areas. Martens are wilderness mammals. They cannot survive in cities, or suburbs, or farm land. They must have great tracts of wild woodland in order to survive. When wilderness disappears, the martens (and other wilderness animals) disappear with it.

The marten is gone from many areas where it once flourished. However, as long as some wilderness (such as the Adirondack Forest Preserve in New York and the National Parks in the Sierra and Rocky Mountains) is saved, the marten will survive ■

ANSWERS TO BRAIN-BOOSTERS APPEARING IN THE LAST ISSUE

1. Did you plant a bird nest?

2. Old oil makes better rainbows.

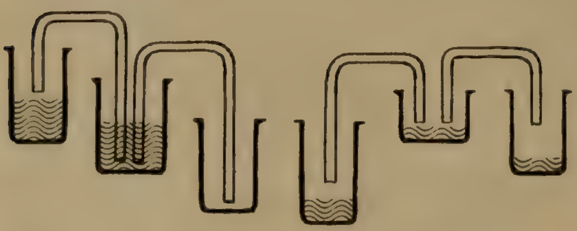
3. Bridge A is strongest. Would this bridge be the strongest if the braces were made of wood instead of wire?

4. The sun softened the wax on the sides of the candles facing the window, making them gradually lean.

5. Photographs are not upside down because they are turned right side up.

6. When the air thermometer is heated, the liquid will go down. The bar will also bend down because copper expands more than steel.

7. The pictures show how the water will be when the siphons stop.



8. The feet belong to these animals: A. Raccoon. B. Fly (house fly). C. Duck-billed dinosaur. D. Ruffed grouse (in winter).

9. One reason that trees lean over a river is because water washes away the dirt from the trees' roots. Can you think of another reason?

10. When soil is put back into a hole it is often compacted more than it was originally.

11. The ruler and hammer arrangement does not fall off the table because its center of gravity is beneath the table top.

A SCIENCE ADVENTURE

Around th

by Jean Le Corbeiller

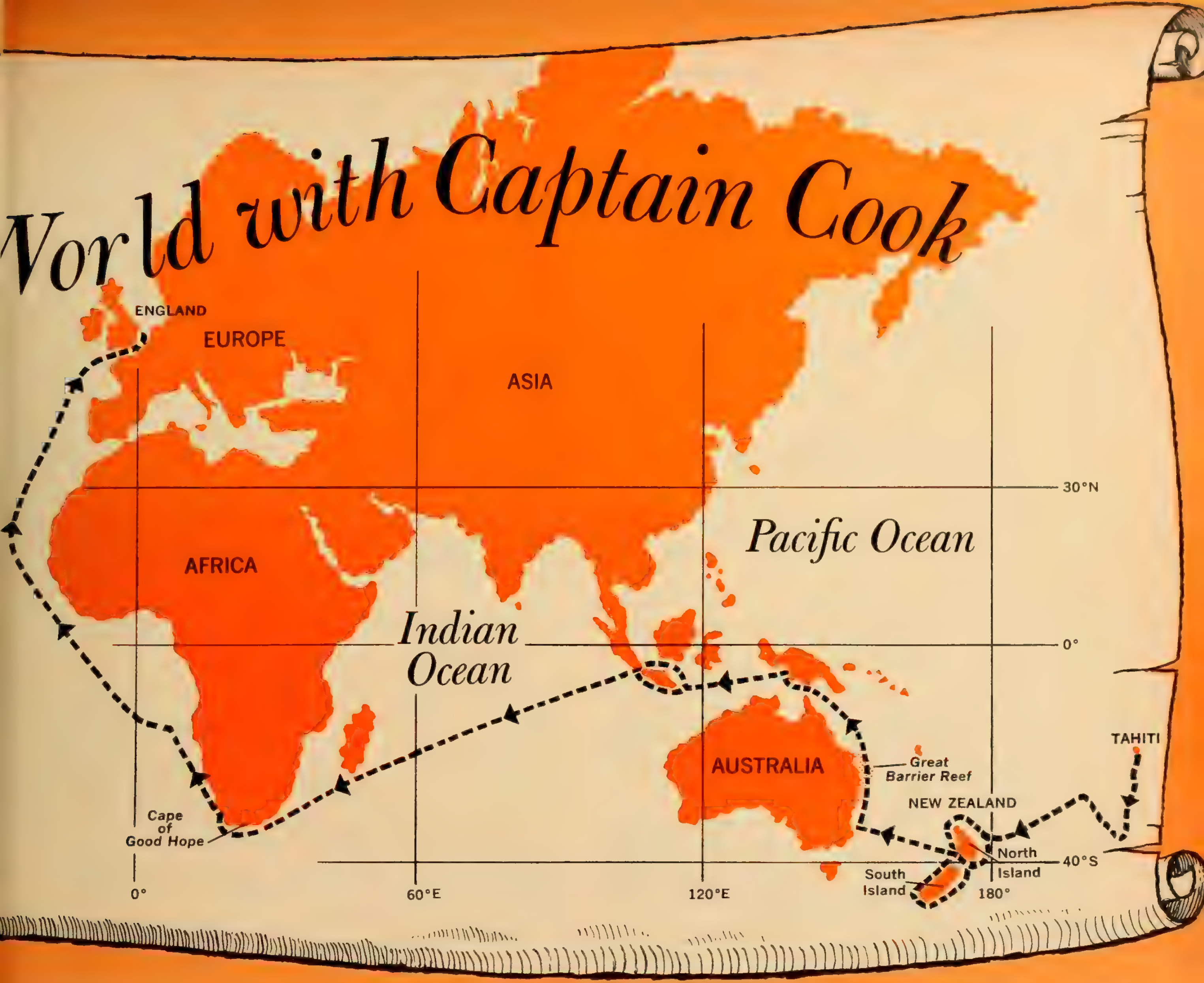
PART 2

Searching vast areas of the Pacific for the "Great Southern Continent," he nearly lost his ship on a gigantic reef, but survived to bring back knowledge that changed the maps of his time.

(In the last issue, Captain Cook and his scientific sta sailed from England to Tahiti to observe the transit o Venus in the year 1769. This work completed, Cook was now ready to carry out his secret orders and explore fo unknown lands in the southern Pacific.)

■ After leaving Tahiti and looking over some of the small neighboring islands, Cook sailed the *Endeavour* southward into the unknown sea in search of the Great Southern Continent. After sailing 1,500 miles without "the least visible signs of land," he headed westward. On October 7, 1769, Nick Young—a 12-year-old boy—sighted land from the mast. Was this the land the Dutch explorer Abel Tasman had seen in 1642? Although Tasman had sighted the west coast of some land about 1,200 miles off the east coast of Australia, he had no idea where the east coast lay. A big question in the minds of many people was how far south and east this land (New Zealand) extended. And, could it be part of the Great Southern Continent? To find

orld with Captain Cook


ENGLAND
EUROPE
ASIA
AFRICA
Indian Ocean
Pacific Ocean
30°N
0°
40°S
AUSTRALIA
Great Barrier Reef
TAHITI
NEW ZEALAND
North Island
South Island
Cape of Good Hope
0°
60°E
120°E
180°

out, Cook would have to sail completely around its shores.

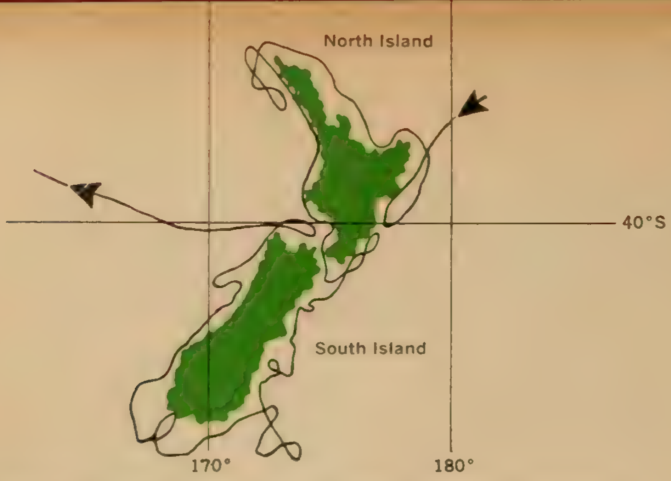
Two Islands for the King

For the next four months the *Endeavour* worked its way around most of what we now know as New Zealand's North Island *(see map)*. Part of the time was spent in preparing detailed charts of their shores—some 7,400 miles of coastline. Cook discovered the strait between the two islands. Tasman had thought that it was a bay. In a formal English ceremony that included setting up a marker with an inscription, hoisting the British flag, and drinking a toast to the Queen, Cook took possession of South Island (as it is now known) for the English Crown. He did all this in front of native Maori tribesmen who had gathered to watch. At the close of the ceremony Cook handed out to the tribesmen silver coins bearing the date 1763.

Cook next sailed down the east coast of the unexplored land to the south (South Island), but at this stage he and

(Continued on the next page)

The ancestors of these Maoris may have performed the traditional poi dance in similar costumes for Captain Cook.



Captain Cook's route around North and South Islands

Around the World with Captain Cook (continued)

his shipmates did not know that it was an island. Could this land be the northern tip of a Great Southern Continent? Cook wondered. Before the ship had sailed very far south, several of the men on board (Banks among them) felt that since they hadn't made a complete, closed circle of North Island, they should do so. Cook turned northward again until he came to a point on the east coast of North Island that everyone remembered having seen before *(see map)*. They then headed southward again.

By March 10, 1770, Cook was sure that South Island was only an island and that he had reached its southernmost tip; in his diary he wrote:

> *I began now to think that this was the southermost land and that we should be able to get round it by the west, for we have had a large hollow swell from the SW ever sence we had the last gale of wind from that quarter which makes me think that there is no land in that direction.*

He was right. He next took the *Endeavour* northward along the west coast of South Island, returning to the strait, today known as Cook Strait.

The Endeavour Sails into a Trap

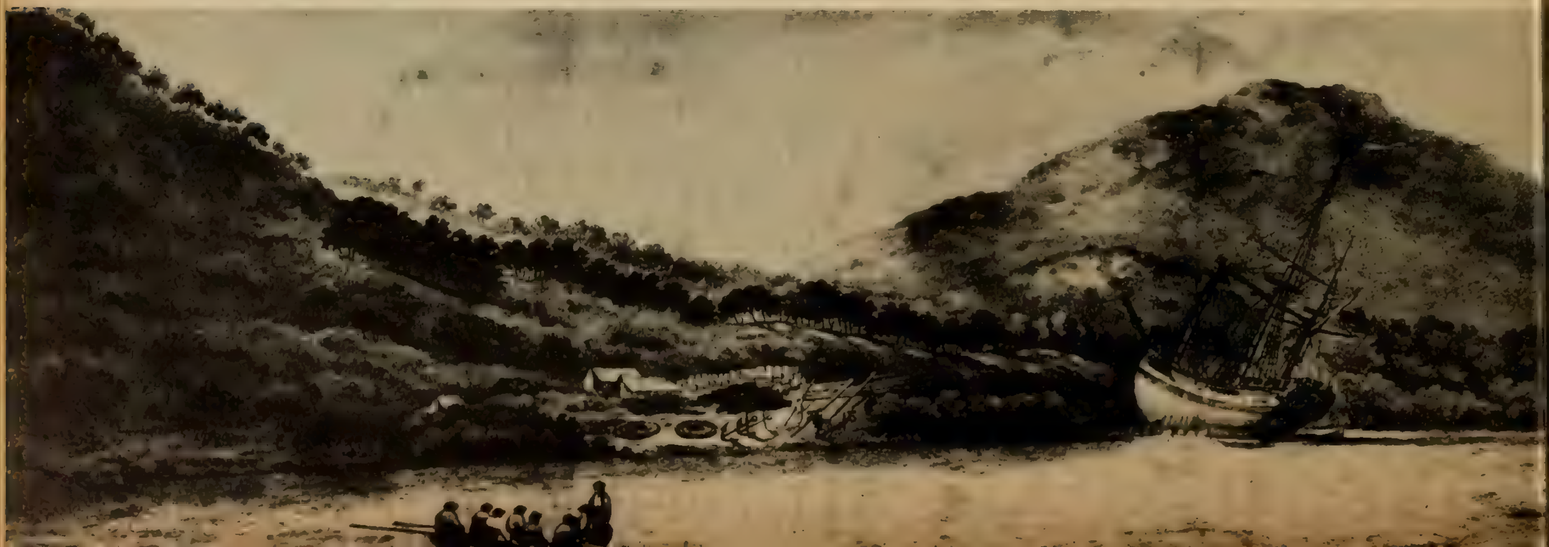
Cook had carried out his orders and was now free to return home. His party had by this time been away for more than a year and a half. He decided to return to England by the Cape of Good Hope, the southern tip of Africa. This would allow him to refit his ship at Batavia (renamed Jakarta on recent maps). It would also put him within reach of the eastern coast of Australia, which he decided to explore before returning home.

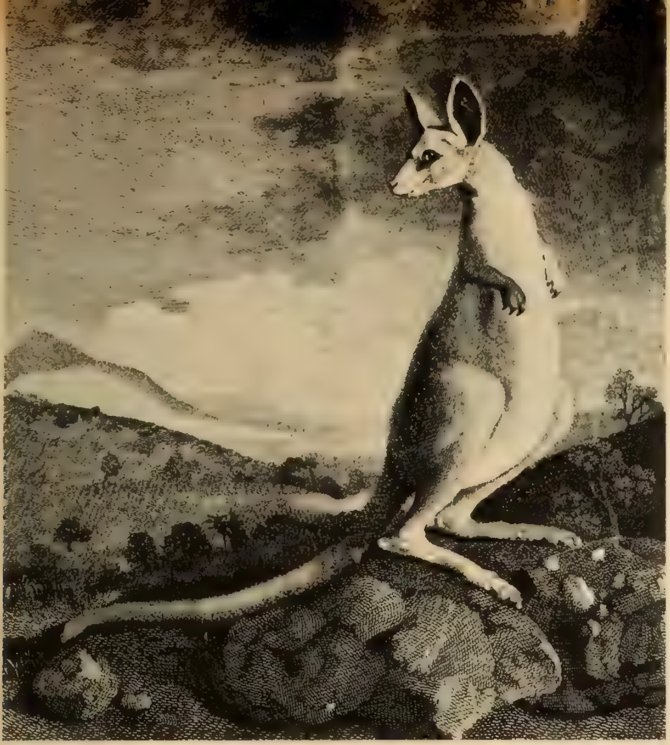
Although the Dutch had explored much of the coast of Australia, no one knew just where its eastern edge lay, or what its landscape was like. And not one of the navigators who had been anywhere near the area had been able to find out. By the time they had reached these remote waters, rot and shipworms (which bore into the wooden hull) had crippled their ships, and the crews were down with scurvy, a disease caused by the lack of certain foods. But Cook knew how to take care of his ship. Although an understanding of vitamins was still 150 years away, Cook's insistence on fresh meat and vegetables for the crew had paid off handsomely. The *Endeavour* had not lost a single man through scurvy.

Cook set off for Australia, and after three weeks found himself near the southern tip of Australia's eastern shore. Because he had only three or four months' food supply on board, he decided to sail northward along the coast without stopping to explore every inlet. He did go ashore for water, however, and had a few brief run-ins with the Australian aborigines—"Indians" to the crew. He had no difficulties in navigating until he had sailed about halfway up the coast, then he fell into a trap.

Lying almost 200 miles offshore—much farther out than the *Endeavour's* course—was the Great Barrier Reef *(see map on page 13)*. Its coral barricades lay almost parallel to the Queensland shore, but inched closer and closer landward toward the north. It was like sailing into the mouth of a long V. On June 10 the *Endeavour* rammed a coral reef, poking gaping holes in her side. Water rushed

This engraving made in 1773 shows the *Endeavour* beached for repairs on the coast of Australia after the ship had rammed into a coral reef. While the carpenters worked, the rest of the ship's company explored the countryside.





Kangaroos were "new" animals to Cook's men. One of them drew sketches from which this engraving was made in 1773.

in so fast that the men working the pumps could barely take care of it. The ship was refloated on the rising tide and temporary repairs were made. The ship would have gone down if a large chunk of coral had not broken off and remained stuck in the hole when the ship floated free. The coral had served as a plug. Cook now had to find a harbor in order to repair the ship properly. The mouth of a river, now known as the Endeavour River, was chosen.

It took the carpenters six weeks to patch up the ship's hull. During that time the rest of the ship's company explored the Queensland countryside. The plants were of great interest to Banks. The one local offering that fascinated everyone was the kangaroo. "What to liken him I cannot tell," Banks wrote in his journal, "nothing certainly that I have seen at all resembles him." After several fruitless chases (even Banks's greyhounds couldn't keep up with the kangaroos), the explorers shot one weighing 84 pounds. They examined it closely, then decided to prepare it for dinner, but they were disappointed with the flavor of the meat. Sydney Parkinson, one of the artists in Banks's retinue, made two drawings of the kangaroo—the first drawings of a kangaroo by a European.

On August 4, nearly two months after the wreck, the *Endeavour* set sail again. A few weeks later, she reached the northern tip of Queensland. As Cook had hoped, open water now appeared to the west—there was a strait between Australia and New Guinea, Torres Strait. Cook reached Batavia in October, and thorough repairs of the ship were now made. It was during this time—10 weeks—that Cook suffered his greatest loss: More than 30 of his men died of malaria or dysentery.

By March 1771, the *Endeavour* was in Cape Town, at the tip of South Africa. On July 12, it was safely back in England. In the three years of the *Endeavour's* voyage, about 40 of its crew had died—but there had not been a single death from scurvy. This was a remarkable record; in those days, scurvy usually took the lives of at least one third of the men on any long voyage.

Cook's greatest triumphs had been the drawing of extremely accurate charts of vast areas of the South Pacific, and adding Australia and New Zealand to the British Empire. He had also enabled mapmakers to show vast stretches of ocean in places where the mysterious Great Southern Continent had been thought to exist.

Although Captain Cook had begun his voyage searching for information about non-living things—islands, a continent, the Solar System—he ended it by discovering wholly unforeseen aspects of the living world—coral reefs, kangaroos, and the strange world of the Maori tribesmen. It was these new realms of the living world that were to be among the great objects of study of generations that followed him ■

Cook's Last Voyage

In July of 1772, Cook was sent to the South Pacific again —this time to search as far south as possible to find the Great Southern Continent. He managed to reach as far as 71 degrees 10 minutes South Latitude, a record that was to stand for nearly 50 years. At this point he found himself face to face with a seemingly endless belt of pack ice barring the way. He wrote:

"I will not say that it was impossible anywhere to get in among this ice, but I will assert that the bare attempting of it would be a very dangerous enterprise and what I believe no man in my situation would have thought of." He also wrote that he was *"well satisfied no continent was to be found in this ocean but must be so far south as to be wholly inaccessible on account of ice."*

Cook's explorations had settled the question of the Great Southern Continent once and for all. He had proved that none existed, and was the first to suggest that a continent of ice probably existed at the South Pole. During this second voyage Cook lost only one man (out of 112) of disease.

In 1776 Cook sailed on his last voyage, again to the South Pacific. After many months at sea, his two ships stopped in Hawaii. The accounts of how Cook met his death are confused. About all we know is that a mob of natives attacked and killed him, then hacked his body to pieces. Cook was only 50 at the time of his death.

BRAIN-BOOSTER CONTEST

For Students, Teachers, and Adults

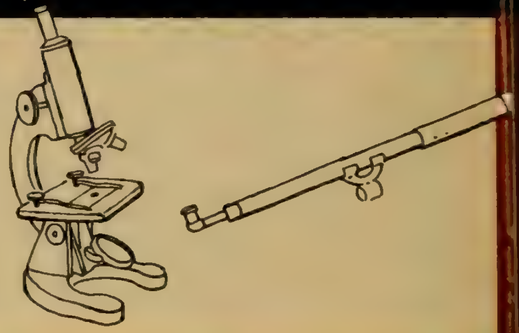
YOU CAN WIN A TELESCOPE OR MICROSCOPE

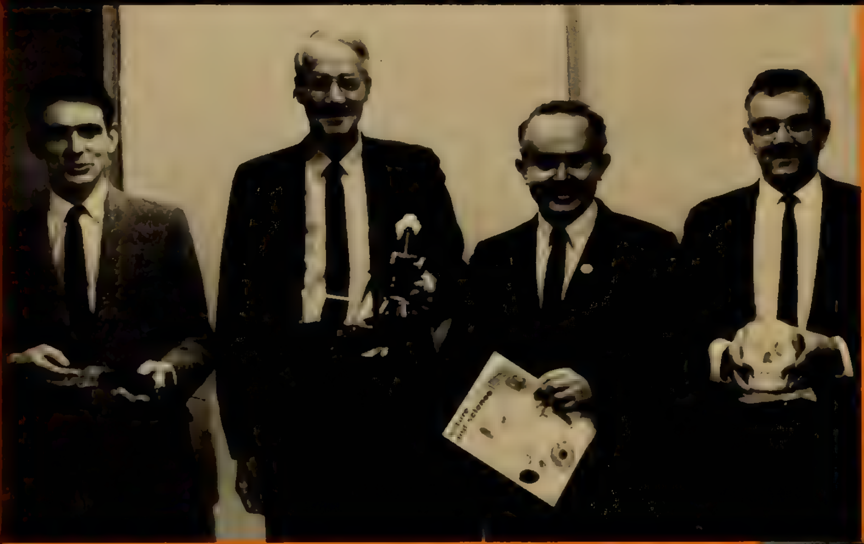
To enter the contest, send the answers to the Brain Boosters below to:

Mr. Brain Booster
Bedford Lane
RFD #2, Lincoln, Mass.

Answers must be mailed by February 25, 1966. *Be sure to include your address, age, and grade in school.* The names of the winners and their answers will be published in the May 9, 1966 issue of *Nature and Science.*

The first prize is your choice of a microscope with 50, 150, and 300-power lenses or a 50-power refractor telescope (see drawings), courtesy of Edmund Scientific Co. Five of these will be awarded, one to the winner in each grade group: 4th grade and below; 5th grade; 6th grade; 7th grade and above; teachers and other adults. The three runner-ups in each group will receive copies of the *Bone Picture Book.*



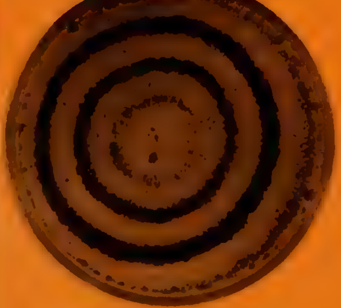


1. Who is Mr. Brain Booster?

You must guess Mr. Brain Booster,
It really will be hard.
Here are some hints, complete with tricks;
You must be on your guard.

I'm not the man who has held here,
The prize of Leeuwenhoek;
I'm teacher, scientist, and yet,
I soon will write a book.

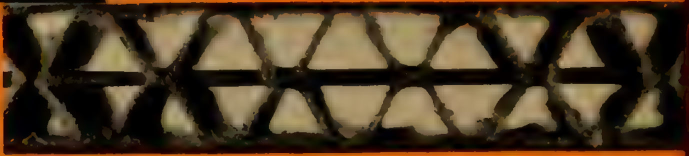
But four of zygomatic arch,
You'll find that I have here;
And aren't you glad that I won't hurt,
Or stab you like a steer?



2. A small piece of mold was "planted" in the middle of the round dish (Petri dish with potato agar). The photograph shows how the mold grew. What shape would the mold have if it had been put into a square dish instead? You can make a drawing if you wish.

3. About how many hairs do you have on your head? Write down your estimate and also tell how you made your guess.

4. If soil comes from rocks, why is there so little soil on the tops of high mountains?



5. What is it?

6. What will happen to the weight of popcorn after popping? Will it weigh more, less or the same? Why?

Using This Issue . . .

(continued from page 2T)

changes in the climate, the plant and animal life also change *(see page 2T)*. Climbing a mountain will take you through a series of vegetation changes similar to those you would see on a long drive north. You will find conditions like those of the Arctic tundra on top of most western mountains and on top of some of the eastern Appalachian chain. Just below the tundra zone is the coniferous forest zone—the environment of the pine marten.

Topics for Class Discussion

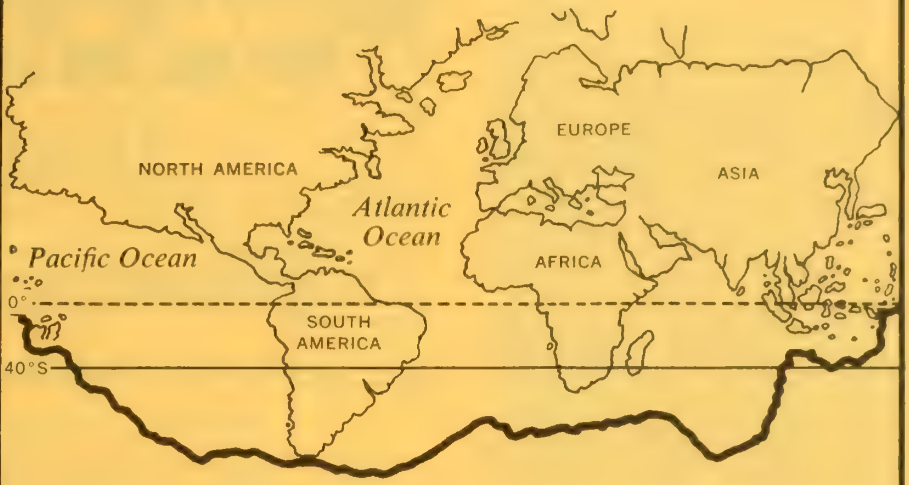
- *What are some rare mammals in the United States?* Martens seem abundant when compared with some other mammals, such as grizzly bear, sea otter, wolverine, wolf, and the black-footed ferret of the plains. Your class might look in conservation magazines (such as *Audubon* and *National Wildlife)* of the past few years to find out what is being done to save these mammals from extinction. There is some information about the status of grizzly bears in "Face to Face with Grizzly Bears," (N&S, *March 15, 1965*).
- In answering the question above, some of your pupils probably listed rare animals other than mammals. (Some rare birds, for example, are the whooping crane and the California condor.) This is a good opportunity to distinguish between *animals* and *mammals*.

The word "animal" is often used when "mammal" is meant. Point out to your class that all life is usually divided into two kingdoms—plants and animals, and that animals include everything from the single-celled ameba to man. One *group* of animals is the mammals, warm-blooded animals that have hair and nurse their young.

- *What kinds of mammals have increased due to changes made by man?* Rabbits and gray squirrels are abundant because they can survive in a suburban environment. Rabbits, in particular, are probably much more plentiful now than they were before North America was settled. They thrive in partly open, brushy habitat, not in mature forests. The same is true of deer.

PAGE 12 Captain Cook

The concluding paragraph of this article points up an idea that is worth emphasizing in class discussion: Captain Cook did not find the mythical land mass that he set out to find, but he did clarify knowledge of the geography of the South Pacific, and in the process he made unexpected discoveries of people, other animals, and plants that have since been the objects of more scientific interest and study than Cook and his party of scientists could have imagined.



This space in the Southern Hemisphere was allotted to the mythical "Great Southern Continent" on a world map drawn in 1596.

Topics for Class Discussion

- *How did the "Great Southern Continent" get on maps if it didn't exist?* Early mapmakers had simply assumed land symmetry in the Northern and Southern Hemispheres *(see map)*. They filled in the unexplored area south of Africa and South America on their maps with an imaginary continent that shrank in size as men, more by accident than by design, sailed across it in latitudes farther and farther southward.
- *What is scurvy, and how did Cook protect his men against it?* Until Cook's time, and even later, the disease called scurvy was one of the worst hazards to sailors and explorers on long sea voyages. Many of them developed the symptoms of scurvy—spongy gums, hemmorrhage, and general weakness—and many died of the disease. For centuries, no one had realized the connection between scurvy and the food eaten by sea travelers. Since there was no refrigeration, they had to carry non-spoilable food, chiefly hardtack (a hard biscuit made of flour and water without salt) and salt pork.

In 1747, the Scottish physician James Lind found that eating fresh vegetables and fruit helped cure and prevent scurvy. Cook must have been aware of this discovery, since he made sure that his crew ate sauerkraut daily, and orange and lemon juices and fresh vegetables whenever they could be obtained. For example, after rounding the tip of South America en route to Tahiti, Cook's men went ashore and collected wild celery, which they ground with wheat and ate each day as "breakfast food."

These measures were effective, and by the end of the eighteenth century, most sailors got daily rations of fruit (especially lime) juice to supplement their hardtack and salt pork diet; scurvy became a rare disease. London's dock area came to be known as "Limehouse" because of the odor of limes stored there, and British sailors gained the label of "Limeys."

By 1920, after vitamins A and B had been discovered, a British scientist suggested that the anti-scurvy substance in fresh vegetables and fruits might be a vitamin also. In 1929 this substance—vitamin C—was isolated from different fruits and vegetables,

(Continued on page 4T)

Using This Issue...

(continued from page 3T)

and was named *ascorbic acid,* from the Greek words for "no scurvy."

Vitamin C works as part of an enzyme system. Enzymes convert plant and animal protein into the specific proteins required by the body. Without vitamin C, the body does not get the needed proteins, and scurvy symptoms develop.

- *Why is the kangaroo so different from any other animal that Cook's men had seen?* The kangaroo is a marsupial, and there isn't a single marsupial on the land mass of Eurasia. The only one in North America is the opossum. Compared with most mammals, marsupials are at a disadvantage before birth in that their environment and nutrition are not controlled by a placenta. After birth, on the other hand, they have the comfort and protection of the mother's pouch. Cook's party apparently did not see any female kangaroos, so they could not have been aware of the pouch.

- *Why are kangaroos found only in Australia?* Australia seems to have been isolated from the rest of the world by oceans for about 80 million years. During that time period mammals in other parts of the world were evolving. Australia's native mammal species include monotremes (the spiny anteater, for example), marsupials, rats, and bats. Bats could have populated Australia by flying there from nearby lands. Rats are notorious for their ability to hitch rides on drift wood and other floating debris and riding it over long distances. It seems likely that the egg-laying monotremes and the marsupials evolved on the Australian continent, and probably had it to themselves until the arrival of man and the dingo (a large, wild dog). Unlike bats and rats, the marsupials were not suited to extensive travel beyond the continent.

To students of evolution, the marsupials of Australia are a showcase of *adaptive radiation.* As marsupials evolved, they filled gaps in animal communities that were taken by other kinds of animals on other continents. Kangaroos, for example, are grazing animals (a role filled by a variety of hoofed animals on other continents). Other kinds of marsupials, such as the Tasmanian wolf, take the role of predators. Still others have habits similar to shrews, rodents, etc.

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TEACHER'S EDITION

VOL. 3 NO. 11 / FEBRUARY 21, 1966 / SECTION 1 OF TWO SECTIONS

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THE PROBLEM OF PEOPLE

by Roger Revelle

(Excerpts from an article of the same name published in Harvard Today, *Autumn 1965 issue. Reprinted by permission of the author.)*

■ Present rates of human population growth confront us with a problem that is unique in the long history of our species. Unless drastic changes in birth or death rates occur, the population increase between now and the year 2000 will be larger than the entire present population of the earth.

Bringing down rates of population growth to a manageably low level will require far more knowledge and experience than we now possess. Economic, sociological, medical, and educational research on a large scale and a wide front are urgently required. The problem may well be the most difficult mankind has ever faced, for its solution lies in controlling one of the basic drives of all living things – to reproduce.

When we try to bring down death rates, every human instinct is on our side. Nearly everyone wants to live longer. Everyone thinks other people should live longer. When we try to bring down birth rates, most human instincts work against us. It is not merely a question of the sex instinct; it is a question of the meaning of life—the joy of having children, the feeling that one is a complete human being only if he has children.

The number of human beings on the earth may ultimately be limited by one or more of many factors—the total energy available for food and material production, the biological and psychosomatic results of crowding, or, more hopefully, the conscious and deliberate decisions of individual men and women.

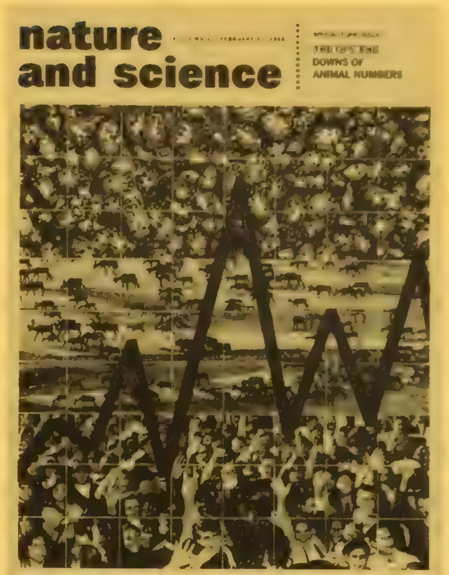
The Costs of Rising Numbers

We in the United States need to examine more closely the social and economic costs of rising numbers of people in our own country. Our population is increasing at about one and one-half per cent a year, considerably less than the rate in the less developed parts of the world. Yet even this rate of growth brings many problems. Increases in per capita costs of pollution abatement, municipal water supplies, outdoor recreation, and urban transportation are all consequences of our increasing numbers. Perhaps more serious is the decline in the quality of life: the crowding and dangers of our parks; the fact that our water does not taste as good as it used to; that many of our fellow citizens waste one or two hours each day driving to and from work under what can only be described as miserable conditions. One has to ask whether juvenile delinquency, student alienation in the universities, and unemployment among untrained youth, are not also partly related to our rapid population growth and, if so, how should this affect our national thought and action?

During the past two decades our rate of population growth was considerably higher than it is today. As a result the number of high school students will increase from 10 million in

(Continued on page 3T)

Dr. Roger Revelle is the Richard Saltonstall Professor of Population Policy and Director of the University-wide Center for Population Studies, Harvard University.



IN THIS ISSUE

(For classroom use of articles preceded by ●, see pages 2T and 3T.)

● Animal Arithmetic
Most animals have the biotic potential to increase rapidly, but over the years their numbers seldom change very much. Food supply, predators, and the need for "elbow room" are some of the things that keep animal populations under control.

● The Missing Lynx
Many scientists believe certain animal populations rise and fall in cycles. Whether this is so—and if so, why—is still a mystery.

Rabbit Rollercoaster
This WALL CHART shows how biotic potential and environmental resistance cause seasonal changes in a rabbit population.

How To Take an Animal Census
Your pupils can sample animal populations and investigate their changes through the year.

● The People Problem
The rapid growth of the human population will affect your pupils, as well as people in more crowded countries. Scientists are seeking ways to ease the problems that result from having too many people.

IN THE NEXT ISSUE

Were the continents of the earth once part of a single land mass?... A scientist tells how animal venoms are studied and how to treat poisonous bites...A WALL CHART compares human parts with machines... Making a simple fire extinguisher ...What happens to plants grown with salty water?

USING THIS ISSUE OF NATURE AND SCIENCE IN YOUR CLASSROOM

2 Animal Arithmetic

This article surveys some of the findings of scientists who study animal populations. You might use the following questions to bring out important points in the article.

Topics for Class Discussion

- *Why do some kinds of animals have more young than others?* In animal communities, some kinds of animals (such as mice, lemmings, and rabbits) are called "key-industry" animals. They support, directly or indirectly, all of the predators of the community. They must reproduce at a fast rate in order to meet the demands of predation and still maintain the survival of the species.
- *Have your class think of "environmental resistance" in their lives.* In other words, what kills humans? Compare living conditions today with those of the Middle Ages or earlier. Medical science has reduced the environmental resistance considerably in the past two centuries, so more infants survive and more women live through their child-bearing years. This has influenced the growth of the human population.
- *What is the "job" of predators in animal communities?* Predators are the "consumers" of the more prolific "key-industry" animals. The relationships between predators and the animals on which they prey have evolved over millions of years. The two groups are interdependent. In fact, although animals like foxes and owls are often called "enemies" of rabbits and mice, the effect of their predation is beneficial to the prey species. Predators tend to capture the less-fit prey animals—the sick, injured, the less-alert. This helps maintain the health and vigor of prey populations.

An appreciation for predators is difficult for anyone raised on nursery tales. You might provoke some discussion on this by writing "the big *good* wolf" on the chalkboard. (For more background information on predator-prey relationships, see these past *N&S* articles: "My Three Years Among Timber Wolves," Jan. 24, 1964 and "Too Many Deer," April 19, 1965. The latter is also available in *N&S* Resource Study Unit No. 104, *You and the Land.)*

- *Are "population explosions" rare or common?* The article emphasizes that such irruptions are rare. Many people think otherwise, due to an oversimplified view of the "balance of nature" (a term that is shunned by most ecologists because it is so often misunderstood). For many people, "balance of nature" brings to mind a teeterboard—if the numbers of one animal go up, the numbers of another go down. In fact, communities of plants and animals are usually too complex for this to happen. The numbers of animals stay amazingly stable. Exceptions to this usually occur where communities are relatively simple, as in the Arctic (*see "Missing Lynx," below*).
- *Why is it important to be able to tell young animals from old when studying animal populations?* By knowing the age composition of a population, scientists can get a good idea of its future. For example, a population may die out completely if it is made up mostly of old animals with few young to replace those that die. By way of contrast, look at the diagram on this page. It shows the age distribution of the 1960 United States human population. At that time, about 31 per cent of all people were 14 years old or younger. An ecologist looking at this number of young (and considering the low death rate) would predict a rapidly increasing population.

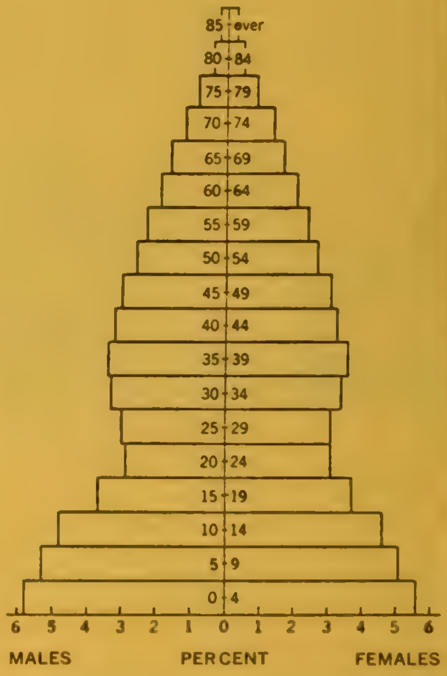
6 Missing Lynx

If your pupils are unfamiliar with graphs, you may have to explain the ups and downs of lynx numbers shown on page 7. A class committee can look in high school biology texts and books on ecology for other graphs that show cycles (*see references*).

Emphasize that cycles are most common in simple Arctic communities where one animal may depend almost entirely on another for its existence. The more plants and animals of different kinds a community contains, the less subject to upset it will be.

The most stable plant and animal communities seem to be in the tropics, which have the greatest variety of life. Ideally, man should be trying to stimulate stability in order to avoid irruptions of insects and other animals. Instead, man is simplifying communities by reducing the variety of life in them. We plant single crops where forests or prairies once existed. Then we spray insecticides which reduce the amount of animal life even more. This leaves the area ripe for an irruption of insects that are immune to insecticides.

(Continued on page 3T)



This chart shows how the United States population was distributed by ages in 1960. At that time almost a third of the people were 14 years old or less.

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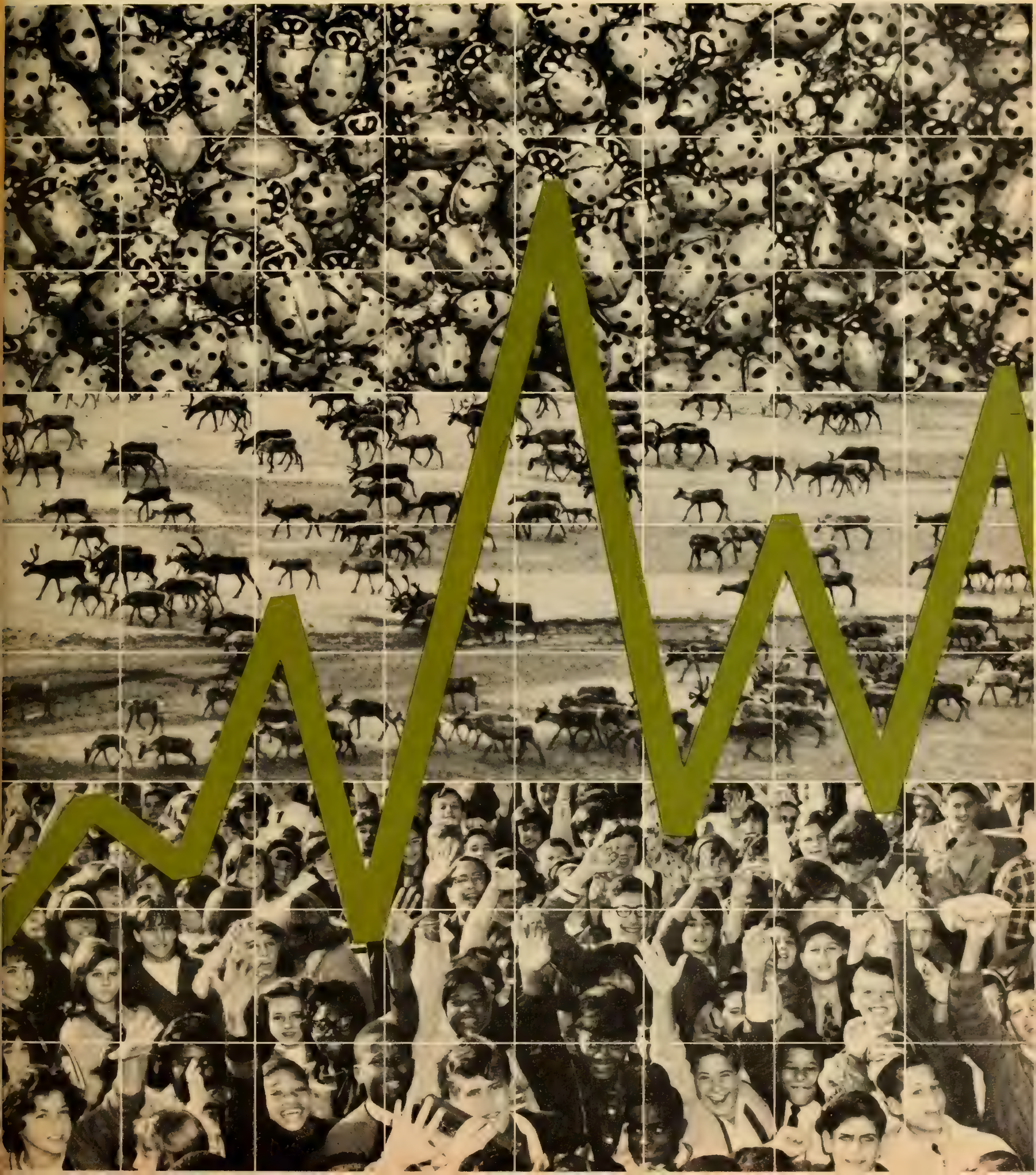
SPECIAL-TOPIC ISSUE

THE UPS AND DOWNS OF ANIMAL NUMBERS



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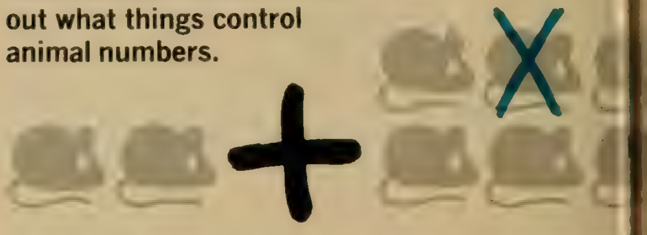
ANIMAL ARITHME

by Dave Mech

If animals multiplied without any subtraction from their numbers, we would soon be up to our eyes in flies or overrun with rabbits. Scientists are studying everything from moose to mice to find out what things control animal numbers.

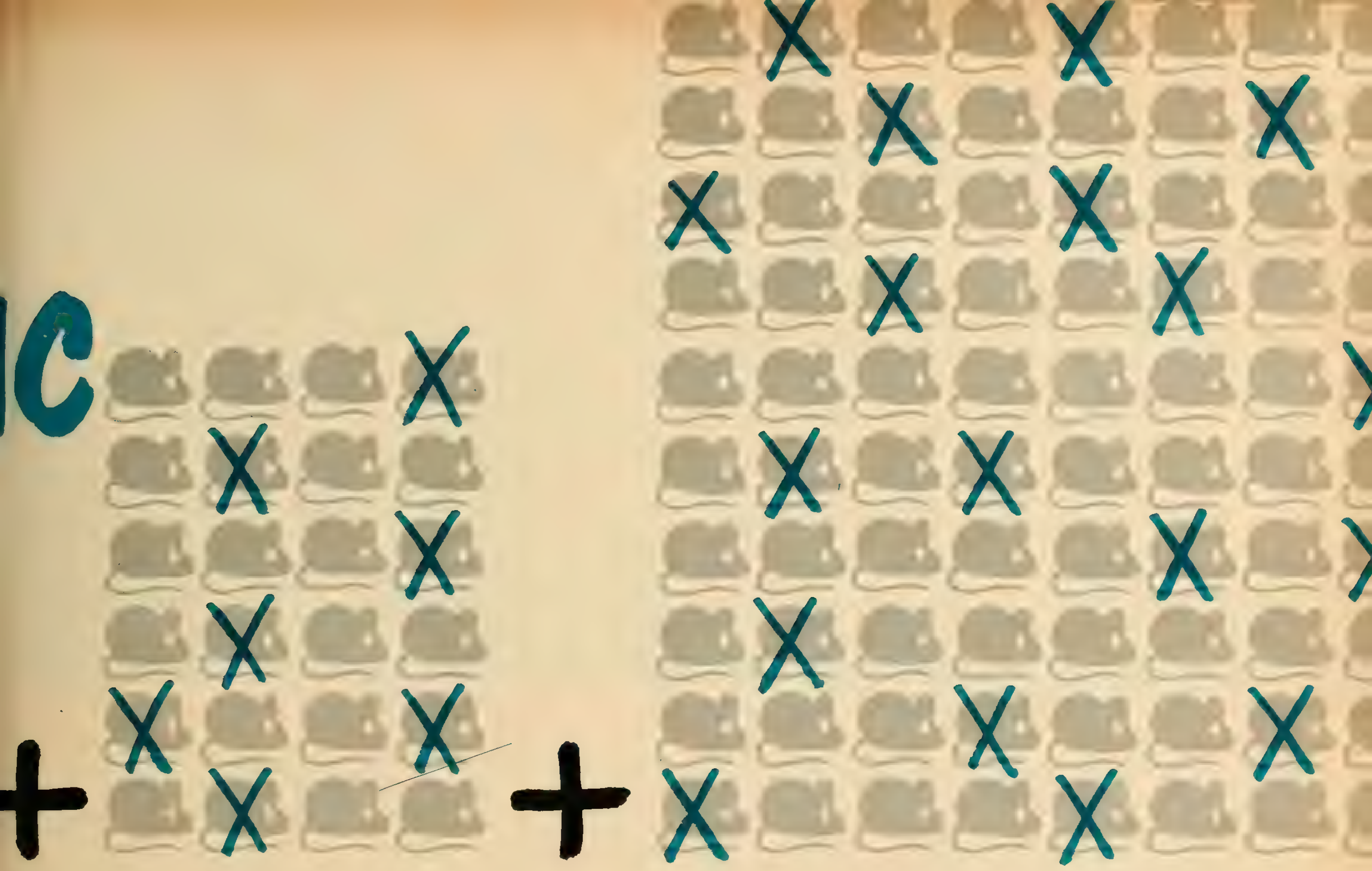


■ Several years ago I wrote an article and made the follo ing claim: "If a pair of mice and their young reproduc for two years and none died, their offspring laid end- end could stretch from New York to California and ba plus 25 times around the earth, and 100 times to and fr the moon; and there would still be enough left over scare all the women in Pittsburgh and feed all their cats a year!"

Recently while re-reading this article, I checked t figures. Sure enough, I had made a mistake. The mi could stretch *200* times to and from the moon!

No, I'm not joking. Let me explain. A pair of field mi can produce young as many as 17 times a year. They ha about 6 young each time. Thus the first pair might pr duce 6, and there would be 8 mice altogether (*see diagra* If half were females, the 4 pairs would then produce 4 tim 6, or 24, making the total 32. So first there would be mice, then 8, then 32. Every litter multiplies the tot number by 4. Now try this. Multiply 32 by 4 and th multiply the result by 4. Keep doing this 10 or 15 tim You will soon see that my claim is true.

So why aren't we overrun with mice? The answer this question comes from scientists called *populati ecologists*. Ecologists study the ways that living things into their surroundings, or *environments*. Population ec ogists study *populations* of living things. The word "pop lation" means different things to different people. Wh



ecologists study animal numbers, they concentrate on a group of animals of one kind that lives in a particular area (for example, the population of bullfrogs in a pond, or the population of crickets in a certain meadow).

Ecologists have studied many kinds of animals to find out why mice and other creatures aren't as plentiful as they could be. What keeps animal numbers under control? The question is a complicated one, and scientists have only part of the answer.

Life Versus Death

As a first step in finding an answer, ecologists need to know how animal numbers change during the year, and from year to year. Thus they must measure populations. To count large animals such as deer, moose, and bears, the scientists may use airplanes. For mice, rabbits, squirrels, and many other species, they set live traps and mark each individual they catch. (In that way they avoid counting the same ones over and over.) When they make their counts, the scientists find that most populations change throughout the year. But from year to year the animal populations usually remain about the same size.

If so many young are produced, how can animal numbers stay the same each year? The only way this can happen is for about the same number to die as are born. If fewer died than were born, the population would grow larger. If more died than were born, the population would get smaller. Since populations usually stay more or less stable, there must be as many deaths as births.

Ecologists explain this stability like this: The size of a population depends on two things. One is the *biotic potential*—an animal's natural ability to increase its numbers. For instance, mice have a greater biotic potential than dogs because they breed more often. The biotic potential, however, is met by the *environmental resistance*—all the forces and factors, such as disease, that work against the animals. In other words, every kind of animal has the ability to increase in number, but forces in their surroundings tend to stop their increase. What is left is the population we see.

These facts have helped answer some questions about animal populations, but they have also led to many other puzzles. What are the factors that hold down population? How do they act? How large can a population get? From what do animals die? Studies of many kinds of animals—from moose to mice—have solved some of these mysteries.

Keeping Numbers Down

In some populations, scientists have found animals dead from starvation. Thus they conclude that food supply is the *limiting factor* on these populations. This is especially true of big-game animals like deer, moose, and elk. However, in other populations of the same species, meat-eating

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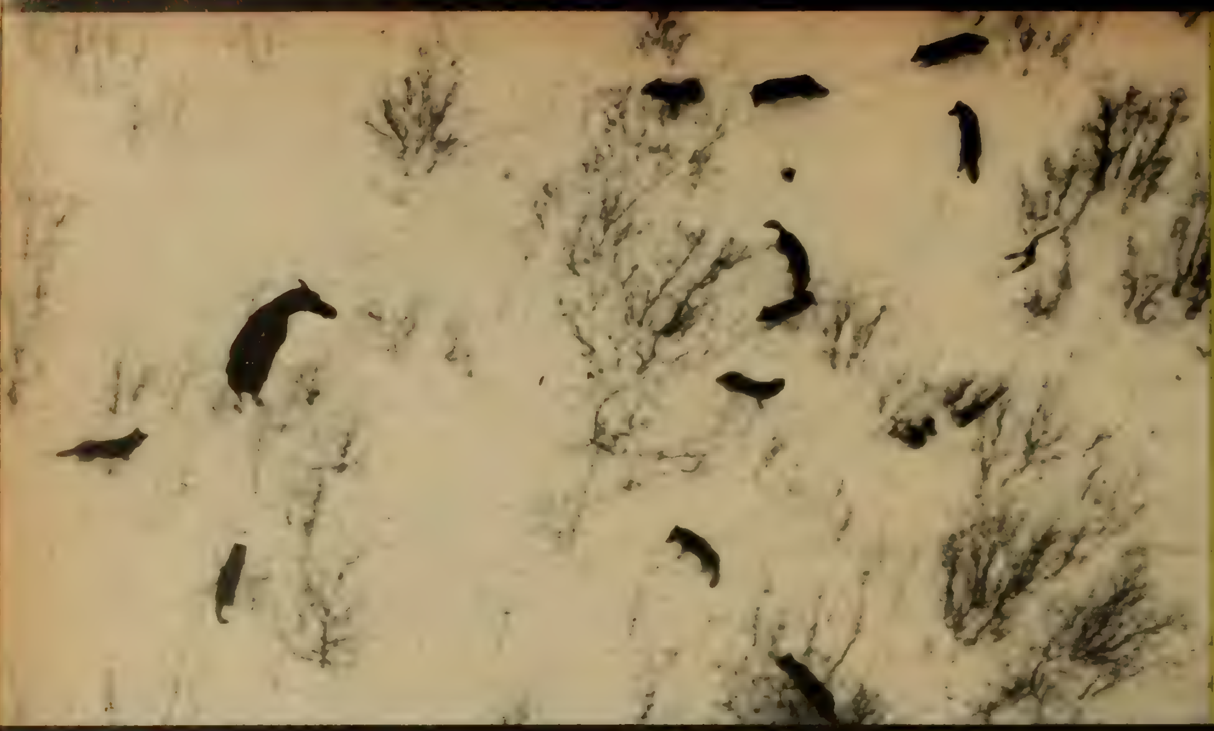


This moose is surroun ed by a pack of wolve The photo was taken c Isle Royale Nationa Park, where wolve keep the moose popu lation in check.

Each of the dar mounds you see in th Michigan marsh is muskrat lodge. Whe muskrat numbers ris too high, the animal die from disease o or from fighting.

Animal Arithmetic (continued)

animals (*predators*) such as wolves kill these animals and control their numbers. For example, Dr. Adolph Murie found that wolves kept down the number of Dall sheep in the mountains of Alaska. My own studies on a large island (Isle Royale) in Lake Superior showed that wolves are keeping moose numbers down. Perhaps predators are the natural limiting factors on big-game populations. After man kills off the predators, however, the number of big-game animals usually depends on the food supply.

Some recent experiments in Georgia showed that predators can also help control populations of smaller animals. Dr. Jay H. Schnell put large numbers of cotton rats into two similar fenced-in areas. One was closed in completely so that no hawks, foxes, or other predators could get in. Dr. Schnell kept track of how many rats were in each area.

He found that in the protected area few rats died. But in the unprotected area the population kept going down until it reached a certain number. This number was about the same as that normally found on a similar size area in the wild. The protected pen supported five times as many rats as the unprotected pen. Thus Dr. Schnell concluded that in the wild there would be many more cotton rats if it weren't for predators.

However, just because predators *sometimes* seem to control animal numbers doesn't mean they *always* do. And it does not mean that without predators, populations would always increase. The late Dr. Paul L. Errington studied muskrat populations in Iowa for over 40 years. He found that predators, especially mink, often killed great numbers of muskrats. Most people would have thought the mink were keeping muskrat numbers down. But Dr. Errington learned that mink killed mainly the "extra" animals—those that did not have a safe place in the population.

Muskrats that were settled in a particular part of the marsh usually had long lives. The extra animals, however, died *even if there were no mink around*. If mink were scarce, then other predators caught the muskrats. If there were few predators, then the animals died from disease or from fighting among themselves.

Dr. Errington also learned that when muskrat numbers were low, the animals produced more young. And the young tended to survive better. Some more evidence like this came from my wolf-moose studies on Isle Royale. There had been high populations of moose on the island before the wolves arrived. Twin calves were rare. After wolves arrived and moose numbers went down, twin calves became common.

It seems that animal populations can adjust in many ways to meet changes in their world. But these inner workings are often tough to figure out. To help simplify their job of finding answers, population ecologists try to get rid of some of the things that affect populations. Then they can study the other factors.

Animals Need Elbow Room

One way ecologists do this is to put populations of mice and rats in laboratory cages. Then the scientists can give the animals all the food and water they want and forget about starvation as a control on the population. The mice are also protected from diseases and from predators—two other controls on their numbers. What do you think happens when these controls are removed? Do numbers just keep going up until the mice overflow out the laboratory doors and windows?

To find out, Dr. John J. Christian (now at the Albert Einstein Medical Center in Philadelphia) and other scientists worked with lab populations of mice. They discovered that mouse populations stopped growing. Some mice just didn't produce young. Others had young but let them die. A few ate their young. Many fought viciously. The only explanation the scientists could find was that lack of space affected the animals. Animals seem to need a certain amount of room or they suffer from what scientists call *stress*. Stress makes animals "nervous."

In laboratory populations, stress seems to directly affect breeding. But this happens when populations are much more crowded than they usually are in the wild. Just how much stress affects natural populations is still not known. Remember Dr. Errington's muskrats? Scientists wonder if stress causes the lower breeding rate found in high populations of muskrats.

Numbers Change, But Not Much

It really doesn't matter what kills animals or controls their numbers. Something does, and populations seldom get too large. On the other hand populations are rarely wiped out completely. Animal numbers change all the time, but they rarely change very much.

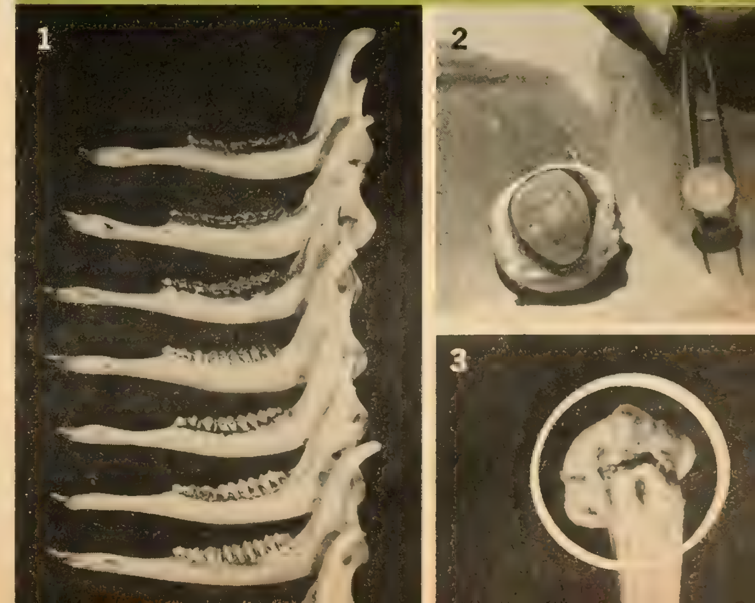
You may have already noticed this. Have you ever seen any great differences in the number of robins, mosquitoes, or ants from one year to the next? Probably not. We do see changes throughout the year however. This is simply because most species have a special season when they breed. Then numbers get large. For the rest of the year numbers go down. The following year it all happens over again (*see pages 8 and 9*).

Since so many animals die each year, this means that most individuals in a population must be young. To test this idea, ecologists had to discover ways of finding out the ages of animals. They have found several ways for doing this (*see photos below*). The age of deer, for example, can be determined by looking at their teeth. The age of rabbits can be figured out by looking at their leg bones, or by weighing a lens from their eyes. Using these methods, scientists have discovered that most rabbits in a population are young. Only about one out of four rabbits is a year old, or older. This is true for most populations of smaller mammals and birds also.

Out of all the millions of different animal populations on the earth, almost all follow this pattern of stability. However, there are a few times when the population controls go awry. Then everyone knows about it. Some older people still remember the year when "army worms" covered the countryside. At times roads had to be closed because they were too slippery from the squashed bodies of millions of these caterpillars. Scientists call such an outbreak of a population an *irruption*.

Irruptions show how great the biotic potential of an animal is. They also give some idea of what would happen if suddenly there were no natural controls on animal numbers. In fact, without these controls we'd all have to stand still; it would be too hard a job to wade through four feet of houseflies. That's how many there would be over the entire earth if one pair of flies and their offspring continued to breed and survive for one year! ■

Ecologists have many different ways of telling the age of animals. The age of deer can be determined by noting the wear on their teeth (photo 1). Rabbits and other animals can be aged by weighing a lens from their eyes (2). A rabbit's age is also indicated by its leg bones, which change as the rabbit changes from a juvenile into an adult.



In northern lands, the population of animals like the Canada lynx go up and down over the years. Ecologists are trying to solve the puzzle of...

THE MISSING LYNX

■ Scientists, like everyone else, enjoy good mysteries. Ecologists have long been interested in a mystery that is still unsolved—something called *population cycles*.

In most animal populations, numbers stay about the same from one year to the next (*see page 2*). The story is different, however, in the northern United States and Canada, especially in the Arctic region. There, the numbers of certain animals do change greatly from year to year. First, numbers go up for a few years, then they suddenly go way down. Then they begin to build again. Because these changes keep repeating, they are called *cycles*.

Population cycles in North America come in two main lengths, one of about four years, the other about 10. The 10-year cycle can be seen best in the yearly numbers of the Canada lynx, a wildcat weighing about 25 pounds (*see photo*).

Ecologists first noticed lynx cycles when they looked at the records of the numbers of animal pelts taken by trappers. Arctic trappers usually sell their furs to the Hudson's Bay Company, which has kept records for more than 100 years. During that time, the lynx catch has tended to go up and then down about every 10 years (*see diagram on next page*). When the catches were highest, trappers brought in up to 80,000 pelts. When they were lowest, only a few thousand of the animals were trapped.

Other animals whose populations seem to have 10-year cycles are snowshoe hares, ruffed grouse, red foxes, muskrats, mink, and fishers (fox-sized mammals related to weasels and mink). It also appears that other species are cyclic in certain parts of the Arctic or at certain times. In fact, some scientists believe they have found population cycles in everything from chinch bugs to tent caterpillars.

The four-year cycles are most easily seen in the numbers of arctic lemmings—mouse-like mammals that live in the far north. According to some people, these animals rush to the sea every three or four years and kill themselves. The story does have a bit of truth to it, for lemming numbers do get very large about every three or four years, and masses of the animals seem to go "mad" and move long distances. At times, some of them even drown in the sea.

What Causes Cycles?

Few scientists have the same views on Arctic population cycles. Some don't even believe there are cycles—they think there is something wrong with the figures. Most ecologists agree that the cycles exist. That, however, is about all they agree on.

Some think the three or four-year cycle is the basic one. According to their idea, every third high point in the cycle is the highest. This shows up as the peak of a 10-year cycle. These ecologists think that all the Arctic cycles are related. A few suggest that some unknown "outside" force causes the cycles. Such things as spots on the sun, moonlight, and amounts of a certain gas in the air have all been blamed for highs and lows of animal populations.

Some scientists claim that cycles come about just by chance. That is, in any string of numbers picked by chance (by throwing dice, for example), the same number will come up every so often. Some scientists believe that chance explains why animal populations reach a peak every so often. By chance, they think, factors favoring high animal populations might show up about every eight to 11 years. With smaller mammals like lemmings, they might occur sooner, causing three to four-year cycles.

Most ecologists believe there is a cause—or causes—for the population cycles other than chance. For example: Could cycles in the numbers of predators, such as lynx, be caused by changes in the populations of the animals that the predators eat? This idea has possibilities. Communities of plants and animals in the Arctic are simple compared to most of the world. Arctic animals tend to depend on only one or a few other animals or plants for food. Thus a change in the numbers of one plant or animal may cause great changes in the numbers of another. For example, lynx depend on snowshoe hares for food. When the numbers of snowshoe hares drop, the numbers of lynx also drop. But this fact still doesn't explain why snowshoe hare numbers have ups and downs.

A few ecologists believe that cycles of snowshoe hares depend on the animals' food supply, the plants. According to this idea, when hare numbers are low, few plants are eaten, so vegetation grows thickly. Then as hares increase, their numbers reach a point where they destroy most of the plants. Many of the hares starve. This gives plants a chance to grow again, and the cycle starts over. The trouble with this notion is that it doesn't fit the facts—scientists seldom find large numbers of plants destroyed, no matter how many hares there are.

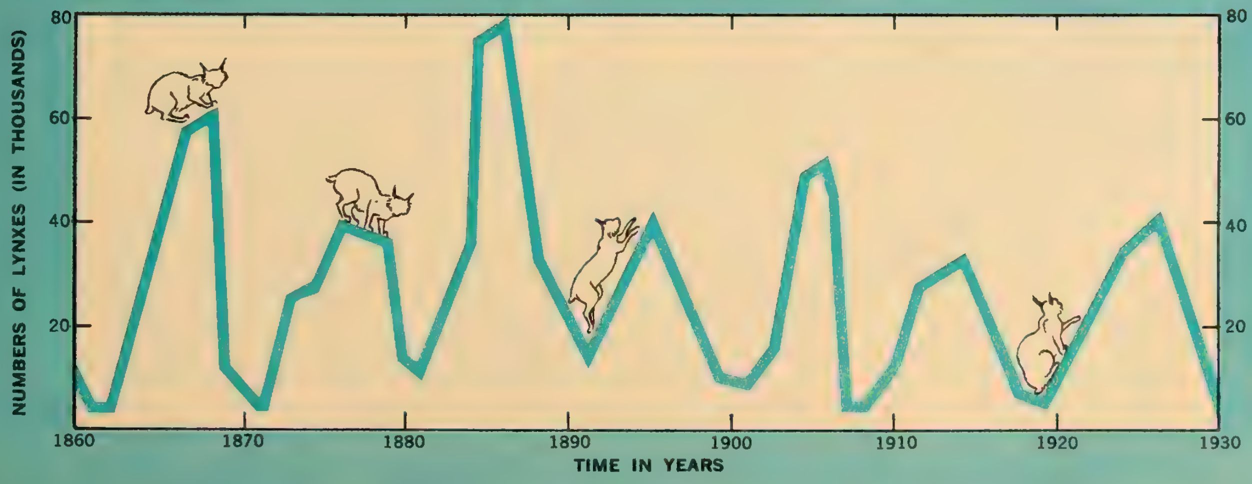
When Stress Builds Up

Another theory is based on something called *stress* (*see page 5*). When animals are crowded together in cages, they suffer from stress, which makes them less healthy. The same is probably true in the wild. As animal numbers in the wild get larger, there is more and more stress. When numbers build too high, the animals have to hunt far and wide for food, and begin to fight. Then a sudden cold snap or blizzard may cause most of them to die suddenly.

It is true that when snowshoe hare numbers "crash" (drop suddenly), scientists find animals dying from *shock,* the result of great stress. Also Dr. Kai Curry-Lindahl, an expert on lemmings, believes that stress could account for the strange actions he has noticed in lemmings at the high point of their four-year cycle. But other scientists say that the stress theory doesn't explain why populations crash about the same time all over the Arctic.

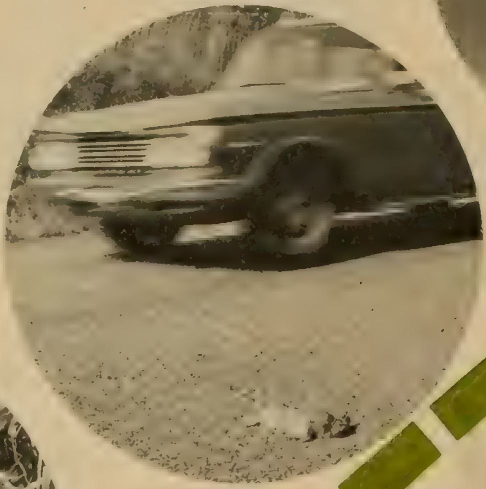
Scientists have worked on this mystery for over 30 years without coming up with a definite answer. Instead they are still asking questions. Do population cycles really exist? If so, are they related to one another? Are they caused by some "outside" force, or do they result from an "inside" force like stress? Population cycles are still a fascinating science mystery.—Dave Mech

This graph shows the number of lynx skins bought from trappers by a fur company from 1860 to 1930. Notice how the numbers reach a peak about every 10 years. These ups and downs seem to be caused by changes in the numbers of snowshoe hares, which the lynx depend upon for food. No one knows why the hare numbers go up and down.

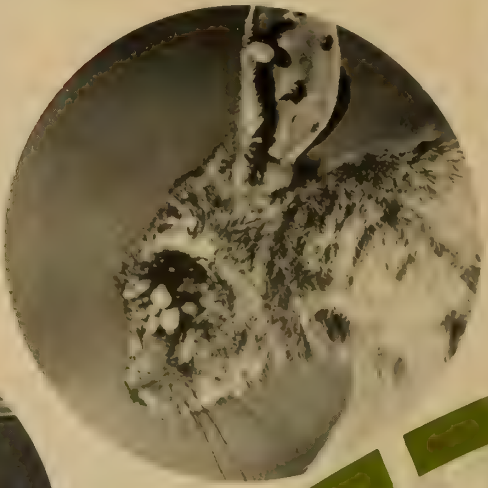


IN THE SPRING, rabbit numbers begin to rise. Cottontails have from one to eight young in each litter, and four or five litters each year. The young are hidden in fur-lined nests until they are about two to three weeks old. But only about half of them live that long. Crows and other meat-eating animals (predators) sometimes find the nests. Other litters are destroyed by fires, floods, or by cold and wet weather.

ACCIDENTS of many kinds kill rabbits.



THE QUIET KILLERS are disease and parasites (plants or animals which live on or in other animals or plants). Parasites of rabbits include ticks (below), fleas, and tapeworms. Parasites seldom kill the animal they live on, but they may weaken it or slow its growth. Then the weakened rabbit is easy prey for some other animal, or may catch a disease.



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■ If you counted the animals in a given area every spr
you would probably find very little difference in th
numbers from year to year. But if you counted the anim
in that same area several times *in one year,* you wo
probably find some big differences in their numbers.

Take cottontail rabbits, for example. They begin bre
ing in the early spring. Soon rabbit numbers start risi
By mid-summer there may be three or four times as ma
rabbits in an area as there were in the spring.

If the number of rabbits continued to grow at this r
for several years, the earth would soon be overrun

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THIS RACCOON is just one kind of predator that depends on rabbits for food. Owls, bobcats, foxes, coyotes, dogs, and weasels are some of the other animals that keep rabbit numbers down. Without these controls, "exploding" rabbit numbers would do tremendous damage to crops and other plant life (as European rabbits have done in Australia and New Zealand).

BIT
COASTER

rabbits. But their numbers do not keep rising. The rabbits are kept in check by other animals, diseases, accidents, storms, and many other factors in their surroundings. Few cottontails live as long as a year. By late winter, just before the rabbits begin breeding again, their numbers are usually back where they were the year before. The same is true of most other animal populations, including those of birds, fishes, and insects.

Starting on the left side of this chart, you can trace the rise and fall of rabbit numbers and discover how and why the population changes during the year ■

PEOPLE EAT RABBITS TOO, and hunters kill millions of them each fall. As leaves fall and plants die in the autumn, there are fewer places to hide and there is less food to eat. The rabbits compete for the food and cover that remains. The high numbers of summertime keep dropping as hunters—both human and non-human—take the surplus.

WINTERTIME reduces the food and hiding places for rabbits even more. The numbers of rabbits drop until they are about the same as the winter before. It is the winter surroundings, then, that determine the rabbit population of an area from year to year. When wildlife biologists try to increase the number of rabbits for hunters, they do not waste time in killing predators or planting summer foods. Instead, they try to increase the amount of food and cover available in the winter.

MER FALL WINTER

SCIENCE WORKSHOP

How to take an animal census

by Laurence Pringle

By catching and counting only a few of the animals in an area, you can figure out the total number of these animals living in the area.

■ An animal population is something like a jar of beans. You can see some of the beans, but it is a long, tough job to count them all. It is usually even harder—or impossible—to count each and every mouse, or ant, or fly, in an area.

Luckily, there are better ways than that to find out the total number of animals in a population. One was discovered about 35 years ago by a biologist named Frederick C. Lincoln, who was working for the United States Fish and Wildlife Service. You can try it out, using a jar of beans (or split peas, or marbles) as your "population."

First take a sample of beans, say one handful, from the jar Count them and jot down the number. Then mark each of these beans with a felt pen or a color pencil and put them back into the jar. Mix the marked beans *thoroughly* with the rest of the "population." Now you have the same number of beans in the jar as when you started, but some are marked.

Next take a new sample of beans from the jar and count them. Jot down the total number of beans in this sample and also the number of marked beans in the sample. Using these two numbers and the total number of marked beans in the jar, you can now figure out the total bean "population."

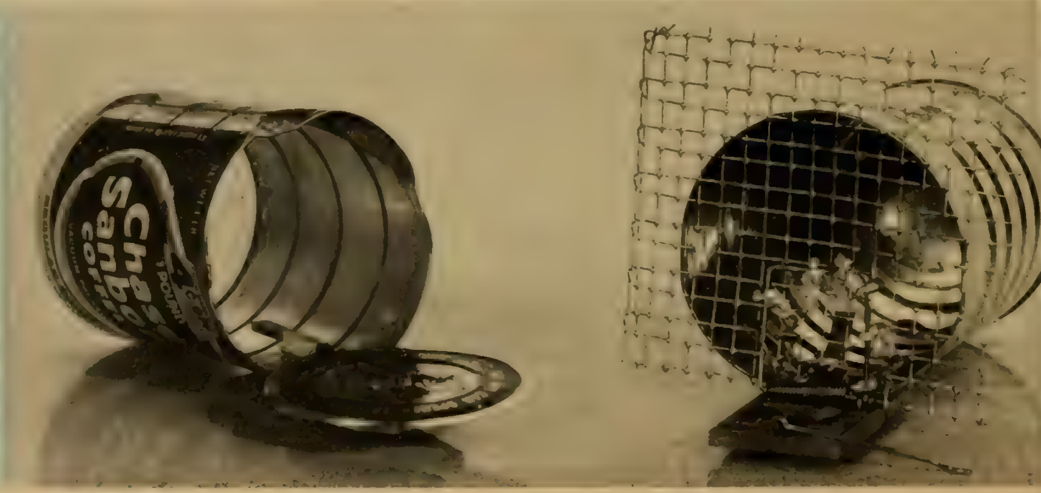
For example, suppose you marked a sample of 60 beans and mixed them in with the unmarked ones. Then you took a second sample of 45 beans and three of them were marked. In this second sample then, there is one marked bean for every 15 unmarked ones (45 divided by three equals 15). This means that there should be about 15 unmarked beans in the jar for every marked one. Since you originally marked 60 beans, multiplying 60 times 15 gives you the total bean population, or 900.

This method gives the *approximate*—not exact—number of beans in the jar. You can count all of the beans to see how close you were.

Counting Mice

You can use this method to estimate animal populations during the coming spring. Suppose you want to discover how many meadow mice there are in a nearby field. (Remember, a "population" means a group of animals of one kind that lives in a particular area.) First, make some simple traps for catching animals alive *(see photo)*. Set the traps among the grass and weeds, spreading them evenly about the area you are studying. Bait the traps with peanut butter or a mixture of peanut butter and oatmeal.

Mice are usually most active at night, so set the traps in the late afternoon or evening and check them early in



To catch small mammals alive, make traps like these from cans and mouse traps. Put an extension on the trap's trigger so that the animals have to go far into the trap before springing it.

the morning. Have a cardboard box, some gloves, and a small can of paint along. When you find a mouse in one of your traps, empty it from the trap into the box so you can catch it easily in your gloved hands. Hold the mouse firmly but gently and mark one of its feet with a dab of paint. (Use enamel, model airplane paint, or fingernail polish that will not wear off easily.) Keep the mouse in the box for a few minutes to allow the paint to dry. Then let it go in the same place where you caught it.

Mark all the mice and other small mammals you catch in the same way. Keep notes on the numbers and kinds of mammals in your traps. *(To identify your catch, see the books listed at the bottom of this page.)* Then wait a few days and reset the traps in the same places. When you check your traps this time, see how many of the marked mice you have caught. Then figure out the total mouse population in the area you trapped (in the same way you would figure the number of beans in the jar).

Of course, life in a wild mouse population isn't as simple as that in a jar of beans. A mouse that you marked may be killed or may leave the area before you trap a second time. Some mice might be lured into your traps more easily than others. These things may affect the results of your investigations, but you will still have a good idea of the total number of animals present.

Counting Other Animals

You can trap, mark your catch, and retrap again in another season to see how the population has changed. Or compare the population of two areas of the same size. You can also keep trapping the same area to learn other things about mice. For example, you may catch a particular mouse several times in different locations. This will give you an idea of the size of the animal's home range. You can also let the animal go in a place several hundred yards away from where you usually catch it. Then see if the animal finds its way home.

Frederick Lincoln's method of counting animals can also be used on even smaller animals. You might try to discover how many sow bugs or pill bugs *(see diagram)* live under some rocks or boards that have been on the ground for some time. Catch (with your hands) as many of these animals as you can and mark their backs with a spot of paint or fingernail polish. Then let them go, and put the rocks or boards back as you found them. Next day, count the number of marked animals you find among the sow bugs present and figure out the total population ■

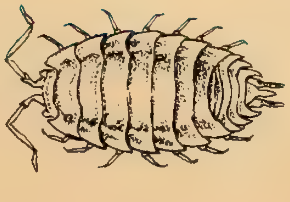
INVESTIGATION

Here is a way that you can investigate animal populations in your own home or school. This summer set out an open jar with some spoiled fruit inside to catch some fruit flies. Or you may be able to rear some fruit flies right now by keeping some ripe fruit (bananas, for example) in a sealed plastic bag for a week or so. There may be some eggs on the fruit that will hatch in that time.

Make a home for the flies in a half-pint bottle with a layer of food in the bottom. To make the food, put equal parts of crushed ripe banana, water, and agar food (available from most drug stores) in a pan and boil the mixture for five minutes. Pour a ¾-inch layer in the bottle and sprinkle a little yeast on top. (The adult flies eat the yeast and the young eat the banana-agar.) Put in the flies and close the top of the bottle with a wad of cotton.

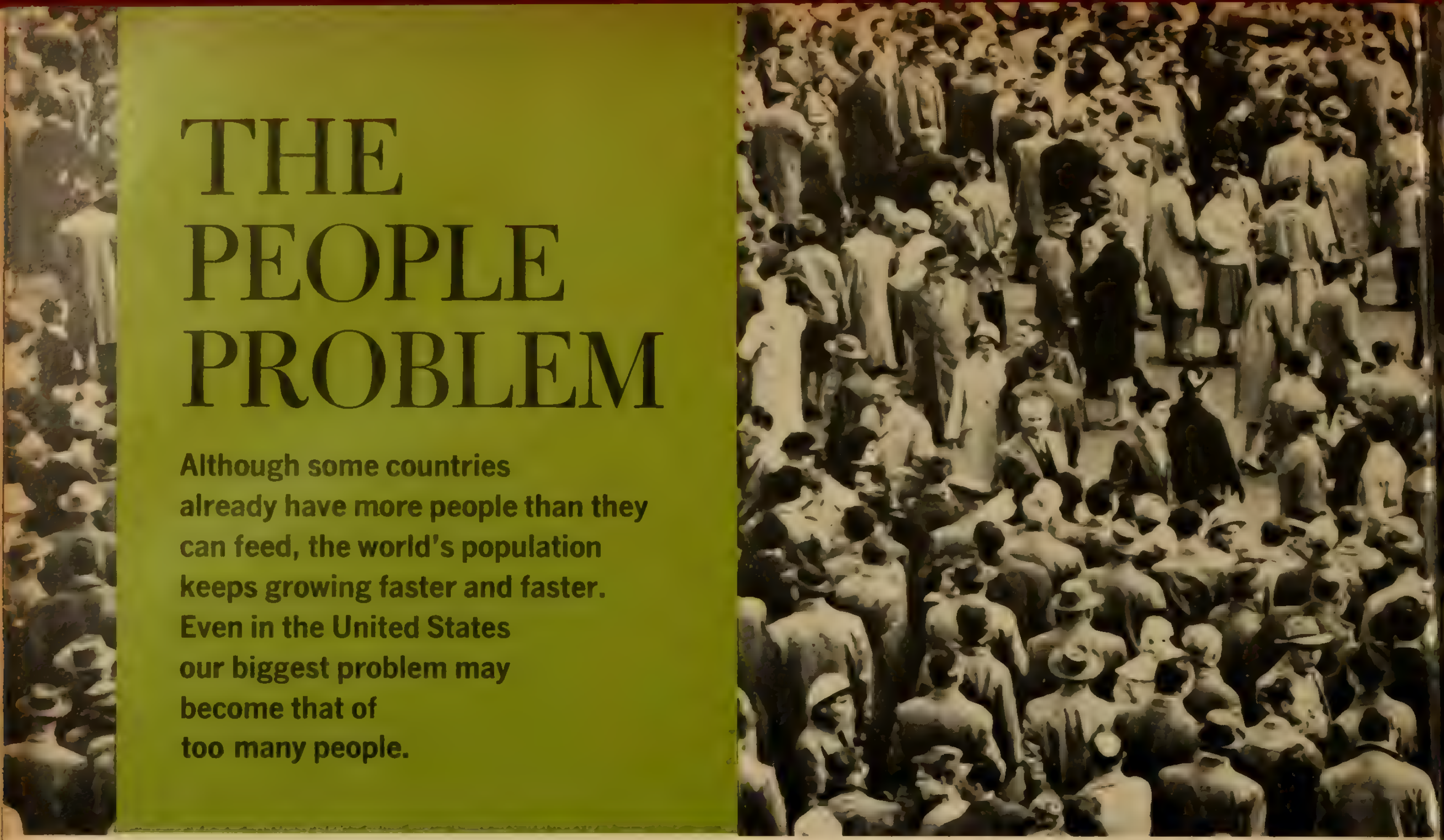
Fruit flies breed quickly, producing a new generation of adults in about 10 days. You may soon have trouble counting all the flies. (To find the total number in the bottle, first count the flies that are resting on a square inch of the bottle's side. Then multiply this number times the number of square inches of surface that the flies are resting on.) You should be able to keep track of the fly population for as long as six weeks. By that time, the food will be used up and the flies will die. It is hard to put new food into the bottle without killing flies or letting them escape.

Keep careful notes so you can see how the fly population changes. What happens when you start fly populations in different-sized jars, or in jars of the same size but with different amounts of food? See if you can discover how the amount of food and space available affects the numbers of fruit flies.



Sow bugs are crustaceans, related to shrimps and lobsters. They are about ½ to ¾ inch long. Pill bugs look similar but are able to curl themselves into a ball-shape.

■ These books will help you identify kinds of mice and other mammals in your neighborhood: **The Mammal Guide,** by Ralph S. Palmer, Doubleday & Company, Inc., New York, 1954, $4.95; **A Field Guide to the Mammals,** by W. Burt and R. Grossenheider, Houghton Mifflin Co., Boston, 1952, $4.95; **Mammals,** by H. Zim and D. Hoffmeister, Golden Press, New York, 1955, $1 (paper).



THE PEOPLE PROBLEM

Although some countries already have more people than they can feed, the world's population keeps growing faster and faster. Even in the United States our biggest problem may become that of too many people.

■ The population of the world on February 21, 1966 will be more than 3,382,700,000. What will be the population in the year 2000? Well, you'll say, that depends on how fast it's growing. If in the course of a year 15 million people die and 15 million babies are born, the population won't change at all.

Right now, for every thousand people in the world, about 38 babies are born each year. Each year about 18 people of every thousand die. So by the end of a year every thousand people in the world will have increased by about 20. In some countries, the population is growing even faster than this; in others, it is growing slower. The figure of about 20 per thousand is a rough average for all of the world's populations.

Last year about 71,250,000 people were added to the world's population–2,330,000 of them in the United States. Each year there are as many *more* human beings on earth as there are now in the British Isles or in West Germany. And all of them need food, clothing, shelter, and education.

This is the situation today. But what of the future? Part of the answer comes from the people who study the changes in population numbers. They are called *demographers* (from the Greek words for "people" and "writing"). When demographers try to predict how big a population will be at some future time, they pay special attention to the numbers and ages of women.

In the United States, for example, women have most of their children while they are between 20 and 30 years of age. If the demographers know how many women in the U.S. are in their twenties now, and how many will reach the age of 20 each year, they can predict more accurately how many babies will be born here each year.

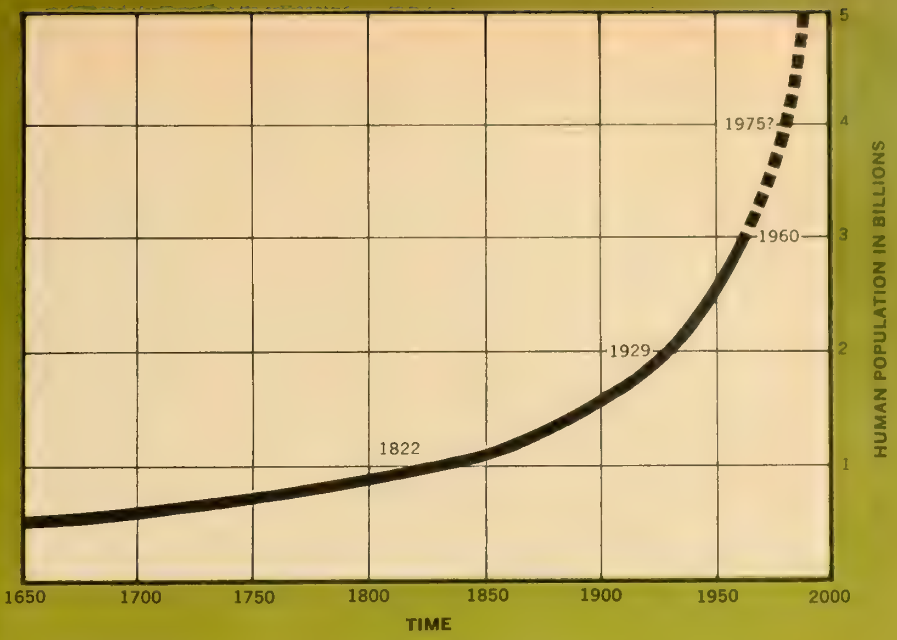
The population of the United States right now is about 196,153,000. This includes an immense number of young girls who will have their own children in the 1980s. Demographers figure that by 1990 there will be about 70 million women of child-bearing ages in the U.S. This is nearly double the number of such women in the U.S. population in 1960. No wonder that demographers predict a population of about 300 million people in the United States by the year 2000.

Like Money in the Bank

We usually think of the population in 1965 as being the population in 1964 *plus* something; and then the population of 1966 as being the population of 1965 *plus* something. But there is more to the arithmetic of population than simple addition–it's a matter of multiplication. (When people talk about rabbits "multiplying" they are quite right; that is just what rabbits do. So do people.)

Think of the way that your money earns interest at a savings bank. Suppose the bank announces an interest rate of 4 per cent, to be paid on your deposit once a year. This does not mean that your deposit of $100 will have $4 added to it each year. It means that your deposit will be *multiplied each year by 1.04* (or 104 per cent).

After one year you multiply $100 by 1.04. The result



The heavy black line above shows how the human population has grown through the years. There were about three billion people in 1960. The dotted line shows how the population will rise if it keeps growing as fast as it is growing now.

is $104.00. After the second year, you multiply $104 by 1.04. The result is $108.16.

That 16 cents looks very small. In the space of five or 10 years it is still small. But when we talk about human populations, we should think much farther ahead than five or 10 years. We are not dealing with money in a bank. We are looking at the future of our world, of our children's world, of their children's world, and so on.

In 1960 the increase in the United States' population was 1.44 per cent (or 14.4 per thousand) a year. If we simply added 14.4 people to every thousand of the population each year it might take our population 70 years to double. But the population of each year is *multiplied by 1.0144*. Because of this, the population of the United States can double in 50 years.

The world population at this moment is increasing at the rate of a little over two per cent a year. If you multiply the present world population (3,382,700,000) over and over by 1.02, it will have doubled in 35 years.

Many People, One Planet

The world's population passed the billion mark about the year 1822. It passed the two billion mark in 1929. The way it is growing now, it should pass the four billion mark in 1975 and could reach eight billions between the years 2000 and 2010.

A "picture," or *graph,* of these figures *(see above)* shows that the time it takes for the world's population to double is getting shorter and shorter. *If* the population continued to grow as fast as it is now growing, it would go up like the dotted line on the graph—as high as you could find paper to draw it. But we are talking about people, not a line on paper. Human beings depend on the earth for survival, and the earth has a limited size.

When it comes to thinking about how many people we can pack onto the surface of the planet, we have to ask ourselves: What do human beings need to stay alive, and from where do they get it?

There isn't a single one of us who can *make* his own food. And a cow or chicken cannot *make* its own food any more than you and I can. One way or another, all animals depend on plants for their food. Plants are the only organisms that can make food by using energy from the sun. When we need protein we eat bread, which is made from wheat (a variety of grass), or we may eat beef, which comes from an animal that has eaten grass. Even the sea food we eat can be traced back to tiny plants that live in oceans and lakes *(see "Who Eats Whom Eats Whom Eats,"* N&S, *Dec. 20, 1965).*

With methods available today, we can make 10 acres of good land yield enough beef to feed one person for one year. Or enough wheat to feed about 15 people for one year. Or enough corn to feed about 21 people for one year. If it is planted in rice and properly watered, the same amount of land can feed about 24 people for a year. How far can we go with this?

Not very far. There is a limit to the land area on

(Continued on the next page)

which we can plant cereals. There are no cornfields in the Gobi Desert. No rice crops are gathered in Times Square, New York City, and it would be a foolish man who would plant wheat on the icy slopes of Mount McKinley.

Where Will the Food Come From?

The amount of land (and water) that can be used to raise food for humans is limited, and there is less and less land available. In the United States, for example, thousands of acres of good farm land are now disappearing under houses, factories, and highways.

However, farming experts are not so much concerned with the amount of the world's farmlands as they are with getting the most from the farmland. "We've been asking the wrong questions," says Lester Brown, an economist for the U.S. Department of Agriculture. He says that the question "How much land can be brought under cultivation?" is not as important as the question "What are the chances for increasing the output per acre?"

The amount of food that is grown on an acre of land has been rising steadily—like an airplane on the takeoff—in the United States, United Kingdom, Japan, and several other countries. Farming experts know why this "takeoff" happened, and they know how it might be brought about in other countries. Yet, they can't do much about it.

According to Mr. Brown, before a country can have a food "takeoff," most of its farmers must be able to read (so that news about better ways of farming can be spread quickly). In India, less than 30 per cent of the people can read.

Such things as modern tools, fertilizers, and tractors are also needed for a food "takeoff." So are ways of transporting tools and fertilizers to the farmers, and ways of getting food from the farms to the cities. All this takes billions of dollars—money which India and countries like it cannot afford.

Starving children are a common sight in poor countries with high populations. The numbers of people are growing fastest in these lands.

You may have read articles in newspapers and magazines about the food shortage in India. Because of a lack of rain in 1965, India's grain crop was far below normal. The United States may send as much as 15 million tons of wheat to India this year—a third of all the wheat grown in the U.S. Sadly enough, one of the problems in keeping great numbers of people from starving is the Indian transportation system. Even if ships bring wheat from the United States to Indian ports, it may not be possible to move the grain to all of the 470 million people who live in that vast country.

Some scientists claim that the earth can support a population of from 10 to 20 billion people, using simple plants like algae and yeasts, and "farming the oceans." But only the richest countries can afford to develop these new resources of food. The poor countries that really need new ways of getting food have little money to spend on such projects.

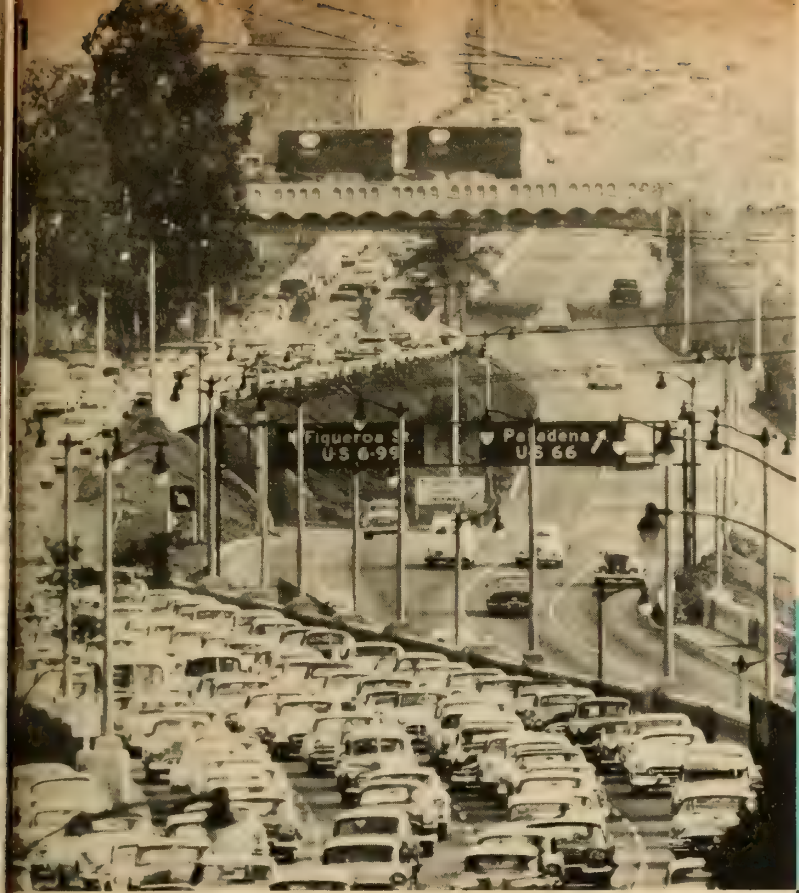
Life Is More than Food

People usually think of growing populations as one problem—that of providing people with enough food. But much more is involved than that. There should be more to life than just staying alive. Even in the United States, with its abundant food supplies, the growing numbers of people are already affecting the "quality of life." The air we breathe is becoming more and more polluted with wastes. Traffic jams are getting worse. Parks, camping grounds, and other recreation areas are overcrowded.

The population of the United States may double in less than 50 years. Think of the changes this will bring to your home town. Your community will probably need many more schools, hospitals, highways, and homes. It will need much more water, more sewers to carry away wastes, and more equipment to remove the wastes from the water so it can be used again. If you could look ahead 50 years, you probably wouldn't recognize your town.

Outside of your community there will be great changes too. Open space will be gobbled up in great chunks for new cities, factories, and highways. Cities and suburbs will spread outward until they join with other cities and suburbs, forming a "megalopolis," that stretches for hundreds of miles.

These changes seem fairly certain. But what about other things? Will there still be any places where people can relax in their free time and on vacations? Will there still be places where people can picnic, hike, hunt, fish, swim, or go boating? All of these things are an important



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Although the United States has no food shortage, the growing population helps cause other problems. Many workers spend an hour or two of their day inching along on "expressways" (1). Parks and campgrounds are so crowded in some areas (2) that they look more like city parking lots. Children that grow up in slums (3) have little chance for a better life.

part of the lives of many people.

What Controls People?

Scientists of many kinds are studying problems that are caused by the growing number of people. Botanists are seeking new varieties of plants that produce more food. Biologists are trying to develop ways of catching more fish and other life from the oceans. Engineers are working on new methods for getting rid of wastes and for making fresh water from saltwater. Doctors are investigating ways of helping people have only as many children as they want.

Ecologists (scientists who study how animals and plants depend on each other and on their surroundings) are puzzled about the future of the human population. In all other animal populations that have been studied, the numbers usually rise to a certain point and then level or drop off. The population may be kept in check by the food supply, by meat-eating animals, or by other things *(see "Animal Arithmetic," page 2).*

But what about humans? What controls their population growth? Will they increase in numbers until the world runs out of food and space? Or is there hope that people themselves will slow down their exploding numbers? Humans, after all, differ from other animals in one important way—they have the ability to think, to reason, and to plan their future. They can see the dangers of having too many people, and they can do something about it ■

3

BRAIN·BOOSTERS

prepared by **DAVID WEBSTER**

Here are some of the best Brain-Boosters sent in by 521 readers who tried to stump me. The ones that stumped me are marked with a star. Of the 651 Brain-Boosters submitted, I could not answer 213, but many of these were codes, riddles ("Why does an elephant have red toenails?"), and nonsense questions ("What is the name of my sister?"). The winners were sent copies of the Bone Picture Book and How To Make a Chicken Skeleton; each will receive $5 for the Brain-Boosters published here.

—MR. BUSTED-BRAIN

★ When a cat is held upside down and dropped, it will land on its feet. Why can a cat or squirrel do this, but a dog or a man cannot?

Submitted by James Boettler, Urbana, Illinois

2 The cold water tap in a bathtub can fill the tub with water in 6 minutes and 40 seconds. The hot water tap can fill this tub in exactly eight minutes. The tub, when filled, will empty in 13 minutes and 20 seconds when the stopper is removed. How long will it take to fill the tub if both faucets are going full blast and the stopper is out?

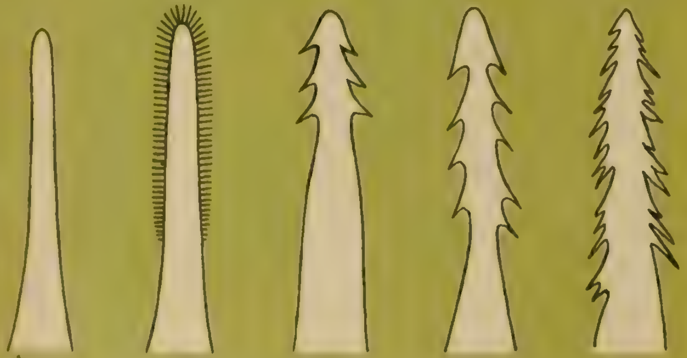
Submitted by Jan Miller, Attica, Michigan

3 My mother lengthened my skirt, which had a 5½-inch hem. On the outside of the skirt the distance from the stitch marks of the old hem to the top of the new hem is 4 inches. How deep is the new hem? (The answer is not 1½ inches.)

Submitted by Louise Holmes, Sayville, New York

★ In the night, my silver ring slides off easily without trouble. But in the morning, I can just barely move it on my finger. It won't budge! Why?

Submitted by Susan Bastress, Lincoln, Massachusetts



★ Can you guess what these are? They are red in color and smaller than they appear in these drawings.

Submitted by Dennine Ranta, Lakewood, Ohio

6 A boy bought some apples. He gave half of all his apples to his father. Then he gave one-half of one apple to his father. He gave his mother half of the apples that were left and one-half of an apple to his mother. He then gave half of the apples left to his brother and one-half of another apple to him. He had one apple left for himself. How many apples did he buy? Remember, he did not buy half of an apple.

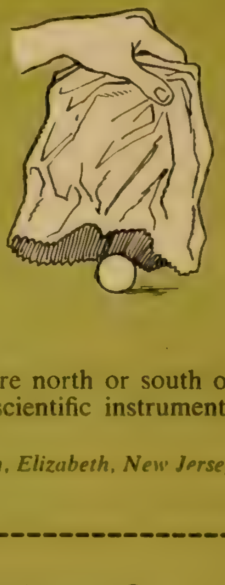
Submitted by Mark Cluskey, Brimfield, Illinois

7 Do you eat rock?

Submitted by Sharon Powell, Clinton, Tennessee

8 When Jimmy took his marbles out of his bag two at a time there was one marble left over. When he took them out of his bag three, four, five, or six at a time, the same thing happened; there was one marble left over. But when he took them out of his bag seven at a time, they came out even. What was the smallest number of marbles Jimmy could have had?

Submitted by Pamela Harges, Holden, Massachusetts



9 How can you tell whether you are north or south of the equator without any aid from scientific instruments or without knowing your location?

Submitted by Ralph Spitzen, Elizabeth, New Jersey

Winning answers to the Brain-Booster Contest announced in the last issue will be published in the May 9, 1966 issue.

Using This Issue...

(Continued from page 2T)

Both this article and "Animal Arithmetic" mention *stress* as a possible controlling factor of animal populations. According to this theory, stresses of various kinds increase as a population increases. The animals have to go longer distances for food or water; they meet many animals of their own kind; fights may occur.

All this puts an extra drain on energy resources at a time when food may be scarce or inferior. The body adjusts to these stresses by increased hormone secretion from the adrenal and pituitary glands. When stresses become too great, these glands "break down," with death resulting.

Other scientists say that the changes in glands are caused by nutritional deficiencies, not by crowded conditions. The matter is still being studied.

PAGE 12 People Problem

Some demographers predict a future when the people on earth won't have room in which to turn around. Obviously, the world's resources would run out before the population ever reached that point. Such forecasts depend on a big if: IF the population continues to grow at present rates.

In the United States, the fertility rate (number of babies born per 1,000 women of child-bearing age) hit a modern low in 1964. It was 123 per 1,000 in 1957, but dropped to 108 per 1,000 in 1964. This compares with a low of 76 per 1,000 in the depression year of 1936. IF this trend continues, the United States might be headed for a nearly stable population, such as already exists in Japan. Again the key word is "if."

There are three ways in which a growing population can be checked: Births can decrease, deaths can increase, or some individuals can emigrate. The prospects for sending millions of human emigrants to other planets are not good, so humans are faced with the other two alternatives.

Topics for Class Discussion

- *When we talk of feeding the world, should we pay attention to quality as well as quantity of food?* When people consider the world's potential for supporting people, they often confine themselves to man's total calorie needs. Have a class committee investigate the nutritional value of the foods mentioned in this article (beef, wheat, corn, rice). Some food scientists say that the world is in a "protein crisis," with a growing gap between population and the amount of available animal protein (from fish, milk, meat, eggs).
- *How would a doubled United States population affect your life? How would great increases in the numbers of people in other parts of the world affect our lives?* Let your pupils imagine how their lives might be changed.

You might point out that such problems as traffic jams, slums, and crowded recreation areas are not due entirely to increased population. The growth in population just accentuates problems that are caused by such things as poor planning and social conditions. For example, the fast-growing demand for outdoor recreation is partly due to increased leisure time.

- *Doesn't the United States have huge surpluses of food?* Yes, but these annual surpluses are getting smaller and smaller. If all the wheat stored in the U.S. were given to the underfed people of the world it would only give them a minimum diet for about two and a half months. Although the United States has surpluses of some food, it must import others—such as meat and fish.

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- "The Human Population," by Edward S. Deevey, Jr., *Scientific American,* September 1960, pp. 195-204.
- "The Urbanization of the Human Population," by Kingsley Davis, *Scientific American,* September 1965, pp. 40-53.
- *Man, Land and Food,* by Lester Brown, Foreign Agriculture Economic Reports, No. 11, 1963, 50 cents (available from the Superintendent of Documents, United States Government Printing Office, Washington, D. C. 20402).

The Problem of People...

(continued from page 1T)

1960 to 15 million in 1970. Within these 10 years we must build new high schools equal in capacity to half of all those now in use in the United States. This is a hard thing for the taxpayers to face, and in general they do not seem really willing to face it. In many communities the quality of our high school facilities is going down.

The number of college and university students is growing from about four million in 1960 to 12 million in 1980. Everybody who has children of college age realizes how hard this is on young people. It is equally hard on the colleges. Both the necessary construction of facilities and the required increase in the numbers of able teachers seem to be almost insoluble problems.

Malthus' "Famous" Theory

In the first edition of his famous "Essay on Population," published in 1798, Malthus reached the pessimistic conclusion that an equilibrium between human births and deaths could be established only at a relatively high death rate. That is, war, famine, and disease, or "misery and vice," as he put it, would kill people off as fast as others were born. Man's fate was to reproduce himself right up to the limit of disease and starvation, and he had no control over what would happen to him.

Some modern "Neo-Malthusians," who share Malthus' early views, claim that the population of any organism will continue to increase until it reaches the edge of subsistence or of control by enemy organisms. They believe this is as true of men as it is of mice or elephants—the only difference being that with different organisms different amounts of time might be required.

History and experience show that this doctrine is bad sociology; recent biological research shows it is bad biology. Experiments with laboratory rats demonstrate that when too many of these animals are forced to live together in too small a space, their behavior patterns become radically abnormal and they effectively cease to reproduce themselves. Wild animals, particularly predators, seem to limit their own numbers in various ways. Some species do this by exercising ter-

(Continued on page 4T)

The Problem of People...
(Continued from page 3T)

ritoriality: Each dominant male controls an area of a certain size, on which he will not allow other males of the same species to encroach, even though he may be indifferent to the presence of males of a different species.

Malthus himself changed his mind before he published the second edition of his "Essay" in 1803. In gathering data for the second edition, he observed that the population of Switzerland had remained nearly static for several generations, even though death rates had substantially declined. He concluded that birth rates must have decreased in proportion to the decline in death rates, and that this was due to the postponement of marriage by Swiss couples until they could inherit or buy enough farm land to support a family. He then added a third process, "moral restraint," to the dismal dub, "misery and vice," which he had previously believed were the only causes of population limitation. His new edition concluded with these (for Malthus) optimistic words:

". . . it is hoped that the general result of the inquiry is such as not to make us give up the improvement of human society in despair. The partial good which seems to be attainable is worthy of all our exertions, is sufficient to direct our efforts, and animate our prospects. And although we cannot expect that the virtue and happiness of mankind will keep pace with the brilliant career of physical discovery; yet, if we are not wanting ourselves, we may confidently indulge the hope that, to no unimportant extent, they will be influenced by its progress and will partake in its success."

Can Man Domesticate Himself?

It is sometimes said that man is a wild animal. Though he has domesticated many other animals, he has never been able to domesticate himself. . . . Throughout most of his existence, man was simply one among many species on the earth. But during the last few millenia he has preempted the planet, its space and its resources. Of far greater importance, we are perhaps the first form of matter in the 20 billion years of the lifetime of our galaxy that has had the ability to understand not only the world but itself. It does not seem too large a step from self-understanding to self-control ■

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nature and science

TEACHER'S EDITION

VOL. 3 NO. 12 / MARCH 7, 1966 / SECTION 1 OF TWO SECTIONS

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◀N&S REVIEWS▶

Recent Natural History Books for Your Pupils

by Barbara Neill

■ Children's books on natural history seem to fall into three categories: those written by writers to fulfill an assignment in a hurry, those written by professional writers who take the time to research their subject thoroughly, and those written by naturalists.

All the books reviewed below are in the last two categories, but quite a number of books on the market fall into the first category. The formula seems to be to read two or three basic books on the subject, water down the information, then condense it to fit the book and use lots of illustrations. The result is usually a mish-mash of half-truths and meaningless generalizations. The writers of good natural history books always know far more about their subject than they ever tell; somehow it always shows.

Monarch Butterflies, by Alice L. Hopf (Thomas Y. Crowell Co., 134 pp. $3.75), is much more than a general discussion of these insects. Besides a thorough description of their life history, there are complete directions on collecting and raising your own monarchs. There is even a section on photographing them. A large part of the book is devoted to the fascinating story of the migration of monarchs and how children can take part in the experiments now going on. The reader learns how to use a rubber stamp on a butterfly's wing or how to fasten a paper tag. The author's enthusiasm will surely make some children want to start one of these projects immediately.

Birds with Bracelets, by Susan Welty (Prentice-Hall, Inc., 72 pp. $3.50), is the story of bird banding. The book tells of its interesting history and about the present-day techniques. Many facts about migration, general habits, and life spans have been discovered through bird banding, but very much more needs to be learned. Mrs. Welty challenges children to help find answers. Both these books are suitable for fourth-grade children and older.

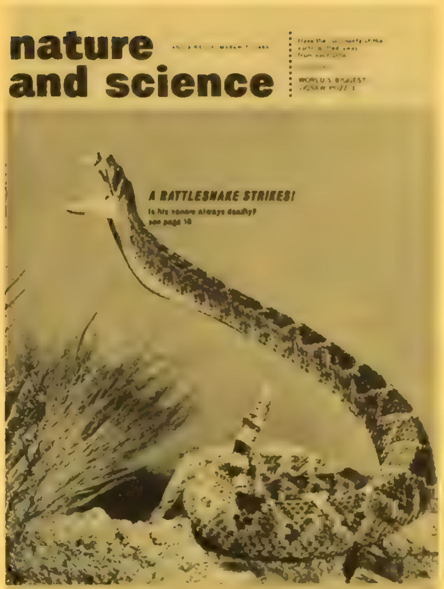
Introducing Our Western Birds, by Matthew F. Vessel and Herbert H. Wong (Fearon Publishers, Palo Alto, Calif., 68 pp.), is a needed book. Many western birds are distinctive, yet the average child's book rarely mentions them. Children in the Far West do not see many pictures of their own brown towhee, red-shafted flicker, bush-tit, or scrub jay. The illustrations in this book may not be everyone's cup of tea. They are decorative and highly stylized. However, the field marks of each species are clear and unmistakable. There are pages of general information and a bibliography.

Honker, by Robert McClung (William Morrow and Co., 64 pp. $2.75). Another book by Mr. McClung is always welcome. Continuing his successful technique of telling the life histories of animals by following one individual, this is the interesting story of Honker, a wild Canada goose. As usual, the information is accurate and the text is a fast-moving narrative simple enough for a fourth-grader.

Dinosaur Hunt, by George O. Whitaker and Joan Meyers (Harcourt, Brace and World, Inc., 94 pp. $3.50). Here is the exciting discovery of the first complete skeletons of the *Coelophysis*, the little dinosaurs which

(Continued on page 3T)

Barbara Neill is a Senior Instructor in the Education Department of The American Museum of Natural History in New York.



IN THIS ISSUE

(For classroom use of articles preceded by ●, see pages 2T and 3T.)

● **Seeds and Salt**
Your pupils can use a homemade balance to investigate the effects of salty water on sprouting seeds.

● **World's Largest Jigsaw Puzzle**
Evidence from fossils and from tiny magnets inside rocks suggests that all the continents may have once been part of one land mass.

● **The Human Machine**
The human body has many parts that work like machines or parts of machines.

● **Poison or Medicine?**
Deadly venoms from snakes, spiders, and other animals have exciting possibilities as life-saving medicines for humans.

How To Make a Fire Extinguisher
This workshop shows how a common kind of fire extinguisher works and illustrates the reaction between an acid and a base.

Tattle-tale Sea Shells
By studying how tiny sea animals grow in different environments, scientists are learning more about the climate in past ages from fossil remains of these animals.

IN THE NEXT ISSUE

Saving the warblers with forest fires . . . What makes your blood a certain type? . . . Tracking down a mysterious poison that killed many Europeans in their homes . . . How mangrove trees make land in the tropics . . . A look at inclined planes . . . How your eyes work together.

USING THIS ISSUE OF NATURE AND SCIENCE IN YOUR CLASSROOM

PAGE 2 Seeds & Salt

The salt residue from irrigation water is a serious agricultural problem in parts of the western United States and northern Mexico. The water of the Colorado River is especially salty, and this river supplies irrigation water over a vast area.

Even if your pupils don't try the investigations in this workshop, they can profit from reading and discussing the article. Talk about the design of the experiment. *Why does Dr. Klein suggest using 20 seeds in each batch? Why not just one?* Individual peas vary just as people do. If you picked one boy from the class, would his height and weight be typical of all the other boys? By choosing 20 peas you increase the chances of finding results that are true of all 100 peas, not just one pea that might be unusual. (A less important reason is that 20 peas can be weighed with units that are bigger and easier to work with.)

Also ask your class: *Since we are trying to find out how salt affects pea seeds, why do we bother putting seeds in tap water and "pure" water?* To learn anything about how salt affects seeds, you must be able to compare them with seeds grown under "normal" conditions—in tap water or "pure" water. The actual *control* in this experiment is the "pure" water, because tap water may contain mineral salts and chlorine that might affect the water intake of seeds. By comparing results you get from tap water and "pure" water, you can get an idea of the tap water's purity. Without a control, the investigation would be meaningless.

Even this small insight into experimental design is an important part of science education. All too many people believe anything that is "proved" by an "experiment." They do not realize that some experiments are poorly designed and prove nothing, or that the results of experiments that are soundly designed can be interpreted in different ways. Such people are easy prey for advertisements and organizations that mis-use results of "experiments" to further their aims.

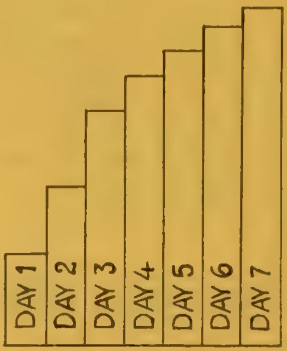
Activities

- You can convert the units of weight suggested in the article to actual metric weights. Also, you can make handy weighing units by making wads of squares of *heavy duty* aluminum foil. Here are some possible units and their metric equivalents:

2¼" square of heavy duty aluminum foil =	.25 gram
3¼" square of heavy duty aluminum foil =	.50 gram
4¾" square of heavy duty aluminum foil =	1.00 gram
1 No. 1 tinned steel paper clip =	.60 gram
1 dime =	2.45 gram
1 penny =	3.12 gram
1 nickel =	4.80 gram

The first weighing (of 20 dry pea seeds) will probably be about two or three grams. A gram equals .035 ounce.

- The results of these investigations can be shown on graphs, plotting the increase in weight against time. In the case of the peas planted in sand, you can measure the height of the plants each day with strips of paper, then paste or tape the strips in order, forming a bar graph *(see diagram)*.



PAGE 8 Human Machine

Making analogies between parts of the body and machines will help your pupils understand both better. This chart can also be a springboard to other studies of the human body and its systems (for example, the heart and circulatory system, the muscles, the lungs and respiratory system).

Activities

- The analogies to machines will make more sense if the children can handle some bones. A human skeleton (borrowed from a high school biology lab, a doctor, or a medical school) would be best, but even a few bones of a dog, cat, rat, or rabbit will be helpful. Be sure to look for hinge joints (at the knees and elbows) and ball-and-socket joints (at the hips and shoulders).
- To explore cartilage, get some chicken (cooked or uncooked) and look at the junction of bones. Remind your pupils of the cartilage between the bones in their heads (referred to as "soft spots" in babies).
- To investigate valves further, see the WALL CHART "Valves All Around Us," *N&S*, Nov. 16, 1964.

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PAGE 4 Jigsaw Puzzle

Since Alfred Wegener proposed that the continents may once have been part of a single land mass, different kinds of "evidence" (geological, fossil, magnetic, etc.) have been discovered that seem to lend credence to the idea. But many scientists suspect that these bits of "evidence" are not necessarily the result of continental drift. For example, it is possible that the earth might once have had two—or more—Magnetic North Poles at one time. And plants whose fossil remains are found on many continents may have been spread by the winds or by birds.

(Continued on page 3T)

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nature and science

VOL. 3 NO. 12 / MARCH 7, 1966

Have the continents of the earth drifted away from each other?

see page 4

WORLD'S BIGGEST JIGSAW PUZZLE

A RATTLESNAKE STRIKES!

Is his venom always deadly?
see page 10

nature and science

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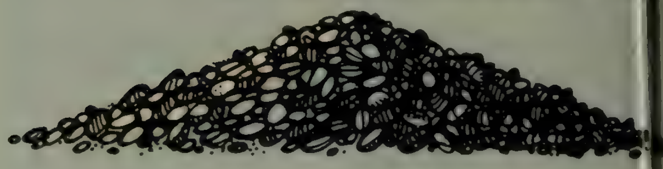
SCIENCE WORKSHOP

SEED



The soil on some farms is getting more salty each ye Is this good or bad? You can use some pea seeds an homemade balance to find out.

■ Each year billions of gallons of water rush through h pipes to farms and ranches in California and the Ameri Southwest and Northwest. Then the farmers either fl their fields or let the life-giving water run along ditches tween the rows of crops. The water sinks into the soil a is used by plants, or it goes into the air as water va *(evaporates).* As the water disappears, the salts that w dissolved in it are left behind on or in the soil.

Year by year the salts increase in the soil. Do you th this helps the crops or harms them? Do plants grow be or worse in salty water? How could you find out?

Testing Seeds in Salty Water

One way is to put some seeds in salty water and comp them with seeds left in non-salty water. When seeds are in water they begin to take up water inside their seed co This process is called *imbibition* and is the first step in se sprouting. The water wets the tiny cells that make up seed and the seed begins to sprout into a plant. You c measure the speed with which water is taken up by se by weighing them. The more water in the seeds, the heav they will be. You can weigh the seeds on a simple balan that you can make at home *(see diagram).*

First you will need about 100 fresh pea seeds from seed store. Divide the seeds into five groups of 20 see each. Weigh each batch of 20 seeds on your balance. this by putting the seeds in the pan on one side of the b ance. Put paper clips, coins, toothpicks, or some oth objects on the other pan to balance the two sides. The see will weigh so many toothpicks, paperclips, or whatever u you choose. Use the same unit as you weigh all five batch

Write down the weights in a table like the one on t next page. Put one batch of seeds in a Pyrex custard di along with ¼ cup of "pure" water (rain water or t

Dr. Richard M. Klein is Caspary Curator of Plant Physiology The New York Botanical Garden. Miss Edsall is his Resear Assistant.

& SALT

y Richard M. Klein and Pamela C. Edsall

WEIGHT OF SEEDS	DISH 1	DISH 2	DISH 3	DISH 4	DISH 5
BEFORE YOU PUT THEM IN WATER					
AFTER ONE HOUR IN WATER					
AFTER TWO HOURS IN WATER					
AFTER THREE HOURS IN WATER					
AFTER FOUR HOURS IN WATER					
AFTER FIVE HOURS IN WATER					
NEXT DAY					

istilled water used for steam irons will do).

Put another batch of seeds in ¼ cup of tap water. Put third batch in ¼ cup of water in which you have dis-olved ½ level teaspoon of table salt. The water for batch should have one level *teaspoon* of salt and batch 5 should ave one level *tablespoon* of salt dissolved in the water. over each custard dish with Saran wrap to keep water om escaping into the air. (If water escapes the salt solu-on will be stronger than before.)

After an hour, carefully take each batch of seeds from s solution and weigh the 20 seeds. Record the weights in e table and return the seeds to the water. Weigh the atches of seeds every hour for four or five hours. Mark own your findings each time. Then leave the seeds over-ight in the solutions. Weigh them again in the morning.

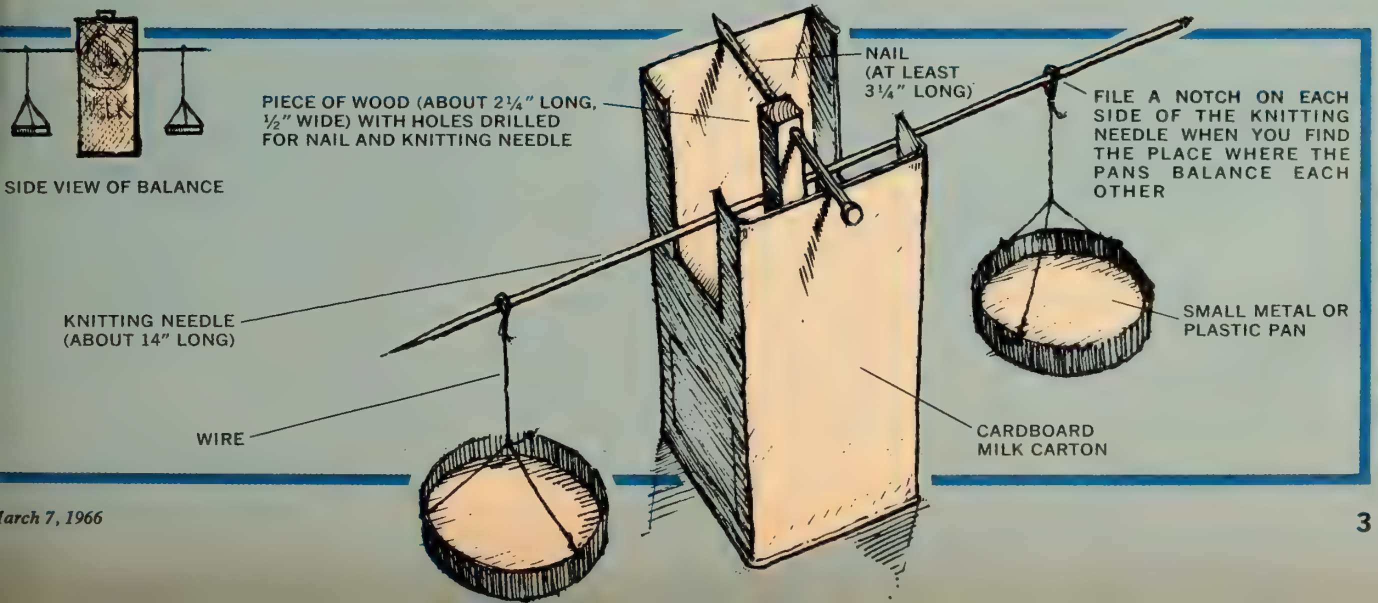
Now look at your figures. Have some seeds taken in water ster than others? How does salt affect the amount of water ken into the seeds? Does salt seem to affect the sprouting f seeds? What might happen to crops grown in salty soil?

xploring Further

You can explore these questions some more, using pea eds planted in sand. Water the plantings daily with “pure” water, tap water, or water containing different amounts of salt. Which seeds sprout fastest? At the end of a week, measure the height of the plants with a ruler. Which ones are tallest? Are there differences in color or in the number of leaves?

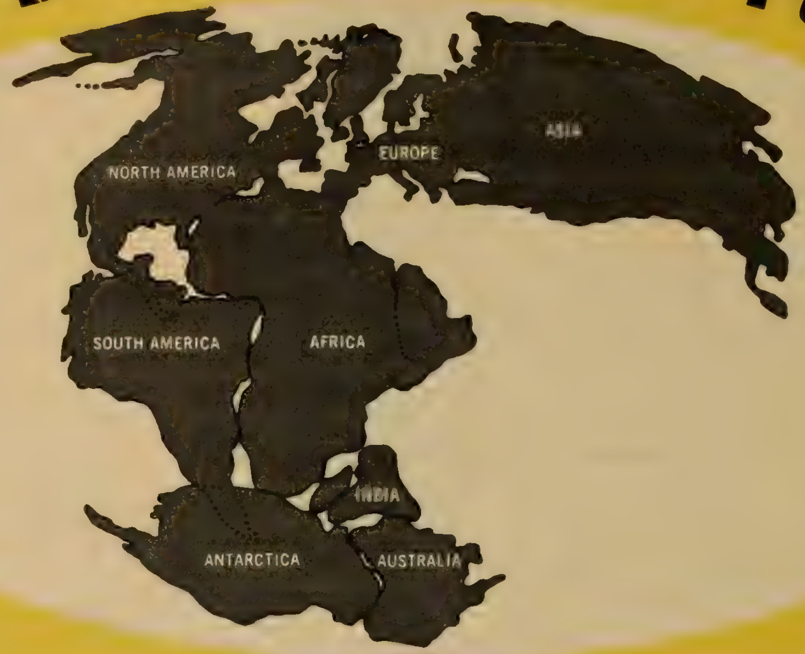
You can use the same methods to see how fertilizers affect the water intake of seeds and early growth in plants. Instead of using salt in the water, use some lawn fertilizer or house plant fertilizer such as Hyponex. Are there differences in plant height after a week? After two weeks?

You can also test beans, corn, mustard, or other seeds to see how they are affected by salt or by fertilizers. If you live near the ocean, collect seeds from seaside plants and test them. Do you think that they would grow better or worse than peas in salty soil? ■


SIDE VIEW OF BALANCE
PIECE OF WOOD (ABOUT 2¼″ LONG, ½″ WIDE) WITH HOLES DRILLED FOR NAIL AND KNITTING NEEDLE
NAIL (AT LEAST 3¼″ LONG)
FILE A NOTCH ON EACH SIDE OF THE KNITTING NEEDLE WHEN YOU FIND THE PLACE WHERE THE PANS BALANCE EACH OTHER
KNITTING NEEDLE (ABOUT 14″ LONG)
SMALL METAL OR PLASTIC PAN
WIRE
CARDBOARD MILK CARTON

A SCIENCE MYSTERY

WORLD'S BIGGEST JIGSAW PUZZLE



BY DIANE SHERMAN

Scientists have some evidence that the continents of the earth have drifted apart. Were they once part of one huge land mass?

■ Nothing seems more solid than the ground we stand on. But the continents beneath us may not be as firm and unmoving as you think. Many scientists believe the continents have traveled great distances during the earth's long history. They say the continents may still be on the move.

About 50 years ago, a German scientist named Alfred Wegener sat in his study, looking at a globe. It was strange, he thought, how the continents were shaped like pieces of a jigsaw puzzle. If South America and Africa were cut out of the globe, they would fit together neatly. Could the two continents have been joined once?

The east coast of North America seemed also to match the western edge of Europe. India, Australia, and Antarctica could be fitted alongside the others *(see map)*. As Wegener studied the shapes of the continents, he wondered. Did the outlines of the continents just happen by chance to fit together? Or *could* all of them actually have been joined at one time, millions of years ago? Wegener's ideas about continental drift were cheered by many scientists, but jeered by others. They said that the continents could not possibly move around. If Wegener were alive today, he would be pleased to know that his continental drift idea is still one of the liveliest topics discussed by scientists who study rocks.

Evidence from Rocks and Fossils

When Wegener began to look for evidence, he found many signs that his idea might be right. For instance, layers of rock on opposite sides of the Atlantic Ocean were very much alike. Rock layers in India, Africa, and Australia were very similar, too. Far apart places like Australia, South America, and South Africa all seem to have been covered by ice sheets 200 million years ago. Wegener thought it odd that the same thing happened at the same time in places so widely separated.

Certain fossils found in different continents were also alike. For example, primitive fossil land plants called *Glossopteris* were found in South America, Australia, India, and Antarctica. This had bothered the scientists of Wegener's day. They found it hard to understand how the same kinds of plants—and certain animals—could evolve in places separated by thousands of miles of ocean. To Wegener, the explanation seemed simple. Two hundred million years ago, all the continents must have been joined as one giant continent. He called the continent *Pangaea* (pan-*jee*-uh), from the Greek words for "all earth." In time, he said, Pangaea began to break apart. The pieces gradually drifted away and became the separate continents we know today.

Wegener's continental drift idea seemed to explain many puzzling facts. It would certainly explain why some rock layers, certain fossils, and ancient climates on different continents were so like each other. But what force could have been great enough to break the continents apart? Wegener said it must be a force that was somehow related to the spinning of the earth. But exactly *what* force? How did it work? Wegener had no good answer.

Clues from Tiny Magnets

Since Wegener's time, we have learned many things about the earth. Today we have new evidence that seems to support Wegener's drifting continents. The new evidence comes from studies of tiny particles of iron in ancient rocks.

You have seen how the earth's magnetic poles attract the needle of a compass, making it line up north and south. When rocks have been formed at various times in the past, tiny bits of iron in them tended to line up with the earth's magnetic poles, just as a compass needle does. When the rocks hardened, these iron "compass needles" became frozen records in the rocks, pointing out the direction of the poles *at the time the rocks were formed.*

By finding out the line-up of the iron particles in rocks *of the same age* that are widely separated on a continent, scientists can figure out where the North Magnetic Pole was in relation to that continent at the time the rocks were formed. From rocks that were formed at *different* times in North America, they found that the direction and distance of the North Magnetic Pole from North America had changed quite a bit down through the ages, as shown by the black line in the diagram below. But a study of rocks in Europe that were formed at different times shows a different "path" for the North Magnetic Pole (colored line).

Two paths suggests that there were *two* Magnetic North Poles, but this seems very unlikely. Then how can we account for two paths? They can be explained if we assume that North America and Europe have drifted apart over the years, each continent moving its own way, independent of the other. So far, studies of the earth's magnetism provide the strongest evidence for the drifting continents idea, but they do not *prove* that the continents have wandered.

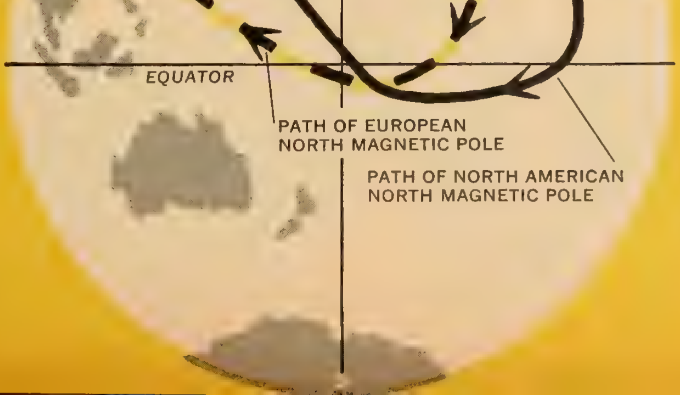
Clues from Mountain Chains

In recent years, oceanographers have discovered a huge undersea mountain chain 40,000 miles long. The longest mountain chain in the world, it starts in the Arctic Ocean, runs down the middle of the Atlantic Ocean, curves into the Indian Ocean, and crosses the Pacific *(see map on page 6)*. Along the ridge of the chain there is a deep crack, or *rift,* about 30 miles wide and two miles deep in places. Oceanographers studying the rift have found that heat is flowing out of it—more heat than is coming from most other parts of the ocean floor. Also, the rift seems to be widening.

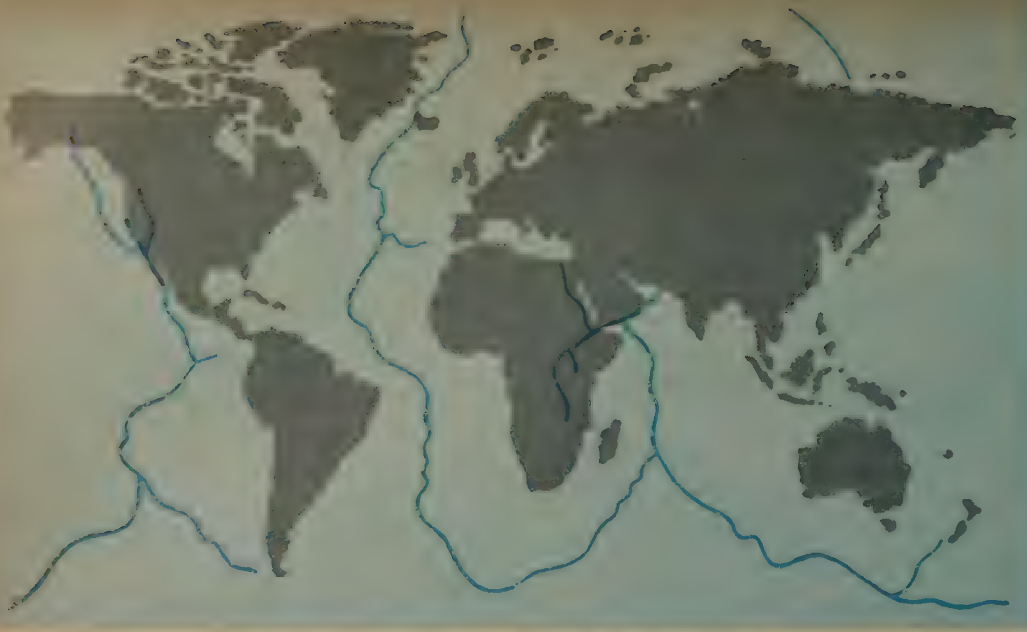
In other places along the ocean bottom, scientists have found great trenches, some nearly seven miles deep, thousands of miles long, and hundreds of miles wide. There is very little heat welling up from the trenches. These and other studies suggest that heat currents are flowing in patterns within the earth *(see diagram)*. Heat seems to be rising beneath the undersea mountains, flowing outward along the earth's crust, and sinking under trenches.

Scientists began to wonder if heat flow along the crust could move the continents along slowly. Possibly, a ridge along which heat is flowing up to the surface would

(Continued on the next page)


N
EQUATOR
PATH OF EUROPEAN NORTH MAGNETIC POLE
PATH OF NORTH AMERICAN NORTH MAGNETIC POLE

The black line on this map shows how the earth's North Magnetic Pole seems to have wandered in relation to North America during the past billion years or so. The colored line shows the "path" that the North Magnetic Pole seems to have followed in relation to Europe in this period. The difference in these two paths up until about 70 million years ago may have been caused by the continents slowly drifting apart.



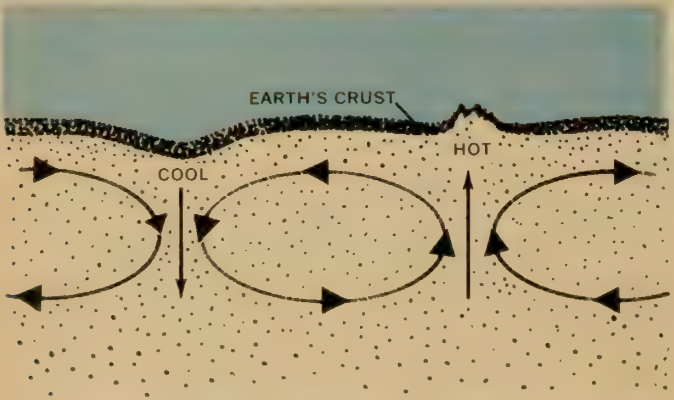
The lines on this map show the location of an undersea mountain chain that is 40,000 miles long. Along the ridge of the chain is a deep crack about 30 miles wide. The crack seems to be widening slowly, and more heat flows out of it than comes from most other parts of the ocean floor.

gradually be split apart. If so, then the ridge running along the middle of the Atlantic Ocean might be one place where the super-continent started to split apart.

If you look at a globe, you will see that there are several island chains like Hawaii dotting the oceans. These islands have been built up by lava pouring out of volcanoes in the ocean floor. The oldest islands seem to be those that are farthest away from an undersea ridge. The youngest ones seem to be closest to a ridge.

Suppose a volcano formed at the ridge. If the heat-flow idea is correct, the volcano would be carried away slowly by heat currents. When new volcanoes formed, these, too, would be carried away in turn. Eventually, there would be several islands, the oldest ones being farthest away.

Possibly this is what has happened in the past, and what is happening today. Just as the islands moved slowly out from the ridge, so, too, the continents may have moved. Another possibility, say some scientists, is that our planet is swelling, like a balloon slowly being blown up. The swelling, they say, takes place as new material deep under a rift wells up to the surface. Gradually the rift and ridge broaden. The Atlantic Ocean may be an old rift that is still broadening.



Heat currents may be carrying rock material upward, sideways, and downward under the earth's crust, stretching the crust and forming mountains in some places, and drawing the crust downward to form trenches in other places.

How the Continents May Have Formed

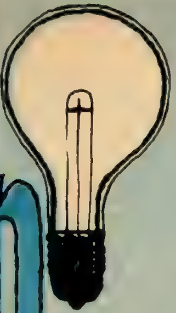
Stanley Keith Runcorn, and others working with him at the University of Newcastle-upon-Tyne in England, think that by 300 million years ago, Wegener's super-continent Pangaea had broken up into two continents—Laurasia in the north, and Gondwanaland in the south. These continents were at first separated by a narrow sea.

Runcorn has described what he thinks may have happened next. In time, he says, the two continents broke up still more. Laurasia broke apart first, with what is now North America moving away from present-day Eurasia. This was caused by a widening of the rift along the mid-Atlantic Ridge. As the rift continued to widen, the continents continued drifting apart. Then, about 200 million years ago, the second continent split, breaking apart and forming South America, Africa, Australia, Antarctica, and India. Gradually they moved to where they are today.

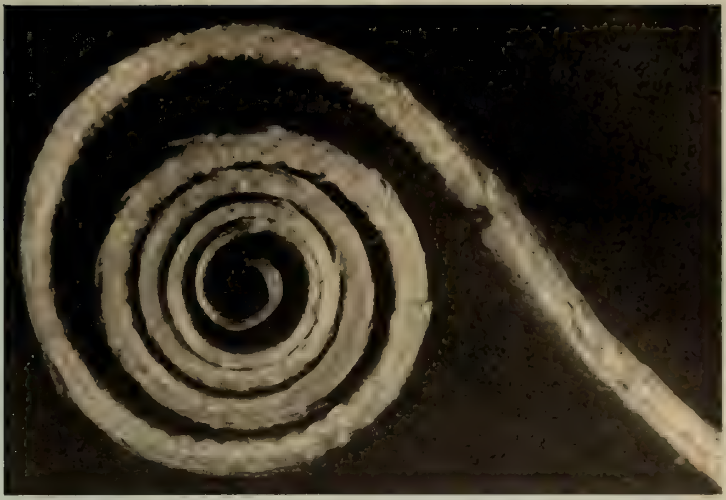
Are the continents moving now? Measurements show that Australia is drifting eastward two inches a year, but we in North America may not be moving. We seem to have been pushed to the spot where the heat currents turn back down into the earth. But this situation may change. Runcorn thinks that heat currents may change their pattern of movements after long periods of time. Should that happen, the continents might be carried off in new directions.

Continental drift is still a theory and we still don't know enough to say if it's true. *Have* the continents moved? One day we may know for sure. In the meantime, scientists will keep on the lookout for evidence to help them solve the biggest jigsaw puzzle in the world ■

Brain Boosters



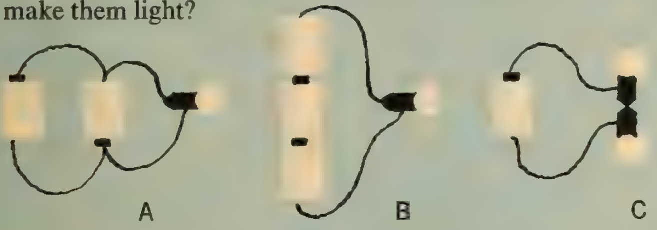
prepared by **DAVID WEBSTER**



MYSTERY PHOTO What is it?

WHAT WILL HAPPEN IF...?

Which of these bulbs will light? What would you do to make them light?



FOR SCIENCE EXPERTS ONLY

What we caught we threw away; what we could not catch we kept. What is it?

JUST FOR FUN

Want to make a liquid tornado? Fill a tall jar with water and get it to swirl around by stirring with a big spoon. Then drop in a few drops of ink or food coloring. What happens to the color?

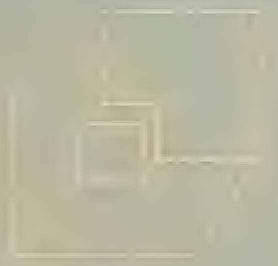
CAN YOU DO IT?

Suppose you had two iron bars, and you knew one of them was a magnet. Could you find out which bar was the magnet, by using just the two bars?

submitted by Nancy Jean Petura, Skaneateles, N. Y.

FUN WITH NUMBERS AND SHAPES

What do you see—
- a little box in a corner?
- a big cube with a little cube cut out of one corner?
- a big cube with a little cube sticking out of a corner?



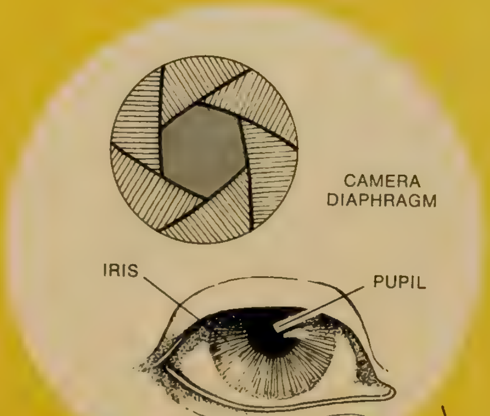
1. A cat can turn over in mid-air because it has a heavy tail. It whirls this in one direction, forcing its body to rotate in the opposite direction. A dog cannot do this because its body is so much heavier than its tail.
2. It will take 5 minutes for the tub to fill up.
3. The new hem is 3½ inches deep.
4. Fluids from the blood continually seep through the walls of the blood vessels. This excess liquid is picked up by the lymph system and returned to the heart in the lymph tubes. Movement of the arm and leg muscles forces the liquid to move through the lymph tubes. At night, when most muscles are not being used, the lymph system cannot remove all of the excess liquid. This causes your body to swell up a little bit during the night.
5. The pictures show the tongue tips of some different kinds *(species)* of woodpeckers.
6. The boy bought 15 apples.
7. Salt is one rock that you often eat.
8. Jimmy had 301 marbles.
9. The North Star is only visible from locations north of the equator.

THE HUMAN MACHINE

■ Even while you are sleeping, parts of your body are working like machines. Your lungs are like a bellows, moving air in and out of your body; your heart is pumping blood. Then, when you're awake and moving, dozens of different parts of your body are pulling, lifting, pushing, working like machines.

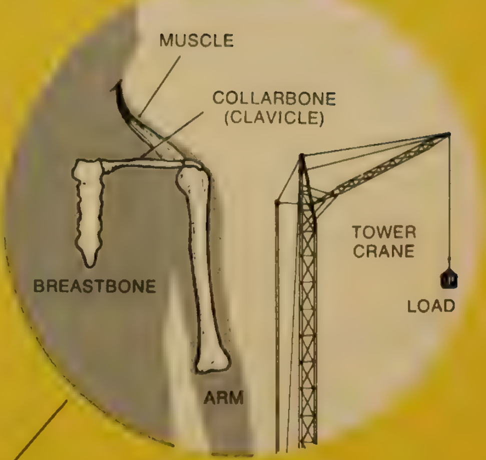
Some of these machine-like parts in our bodies may have given ideas to men of old when they invented tools and machines. There is one part of many machines, however, that doesn't exist in our bodies. That is the wheel. For a wheel to turn it must be completely free of any other part. All the parts of the human body are connected in some way—by muscles, nerves, and blood vessels—so there are no wheels in your body.

The illustrations on these pages show some of the parts of your body that work like machines or parts of machines. Can you think of others? ■

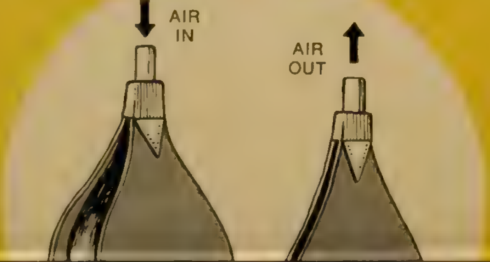


Your camera may have an adjustable diaphragm. You can close it part way to let in less light or open it to let in more light. A ring of muscles in your eye automatically does the same thing, adjusting the size of your eye openings *(pupils)* by moving parts of your *iris.*

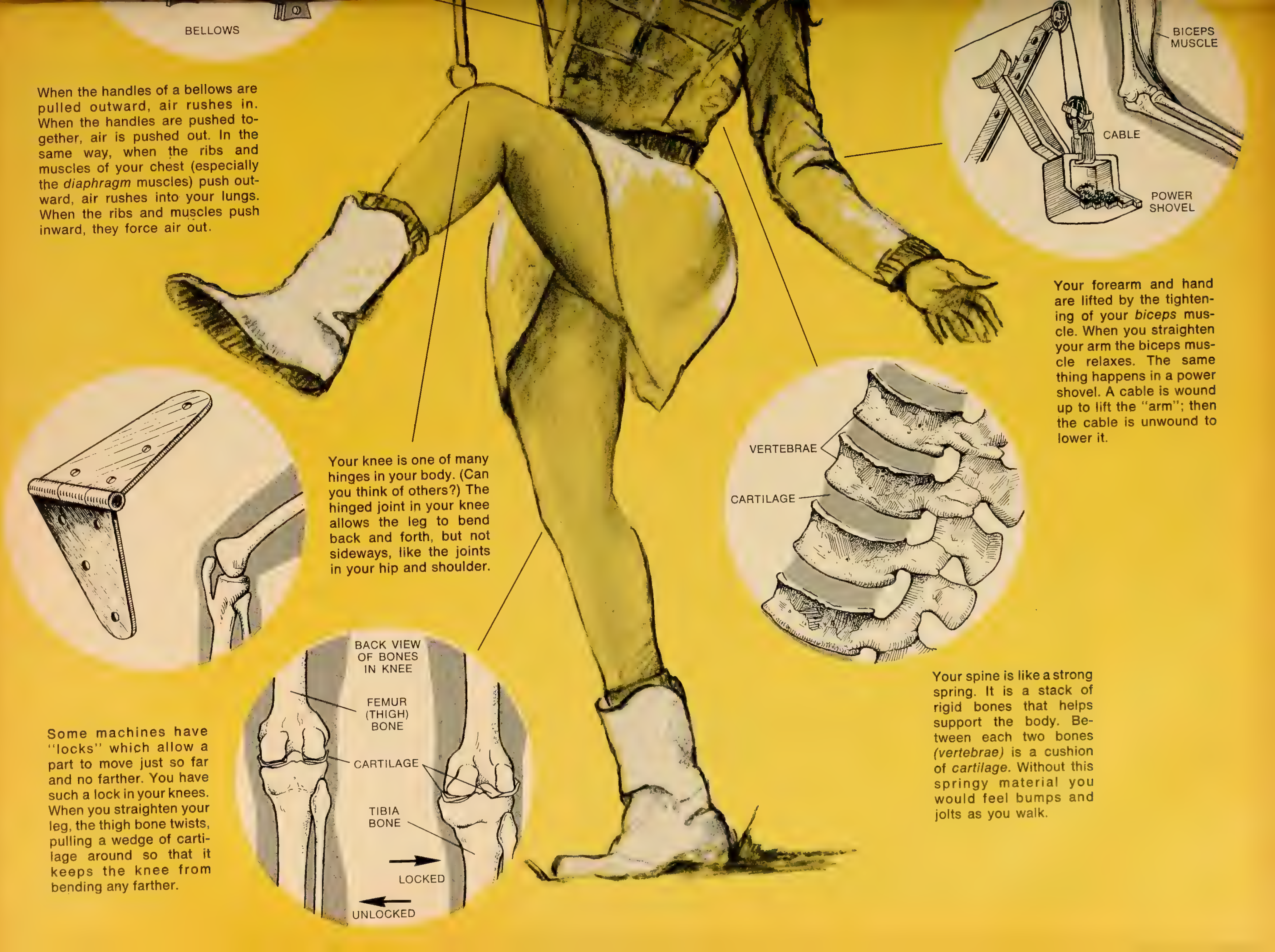
A tower crane is used to lift heavy objects to the top of buildings and to other high places. The muscles and bones of your shoulder support the weight of your arms as a tower crane supports a heavy load.



Many machines have valves that control the flow of liquids, gases, and many other things, including electricity. Your body also has many valves, especially in your heart, veins, and arteries. Even your mouth is a sort of valve.



Your heart is a muscular pump. As its muscles stretch and squeeze, the heart pushes blood through tiny pipes to all parts of the body and pulls it back again.


BELLOWS
BICEPS MUSCLE
CABLE
POWER SHOVEL
VERTEBRAE
CARTILAGE
BACK VIEW OF BONES IN KNEE
FEMUR (THIGH) BONE
CARTILAGE
TIBIA BONE
LOCKED
UNLOCKED

When the handles of a bellows are pulled outward, air rushes in. When the handles are pushed together, air is pushed out. In the same way, when the ribs and muscles of your chest (especially the *diaphragm* muscles) push outward, air rushes into your lungs. When the ribs and muscles push inward, they force air out.

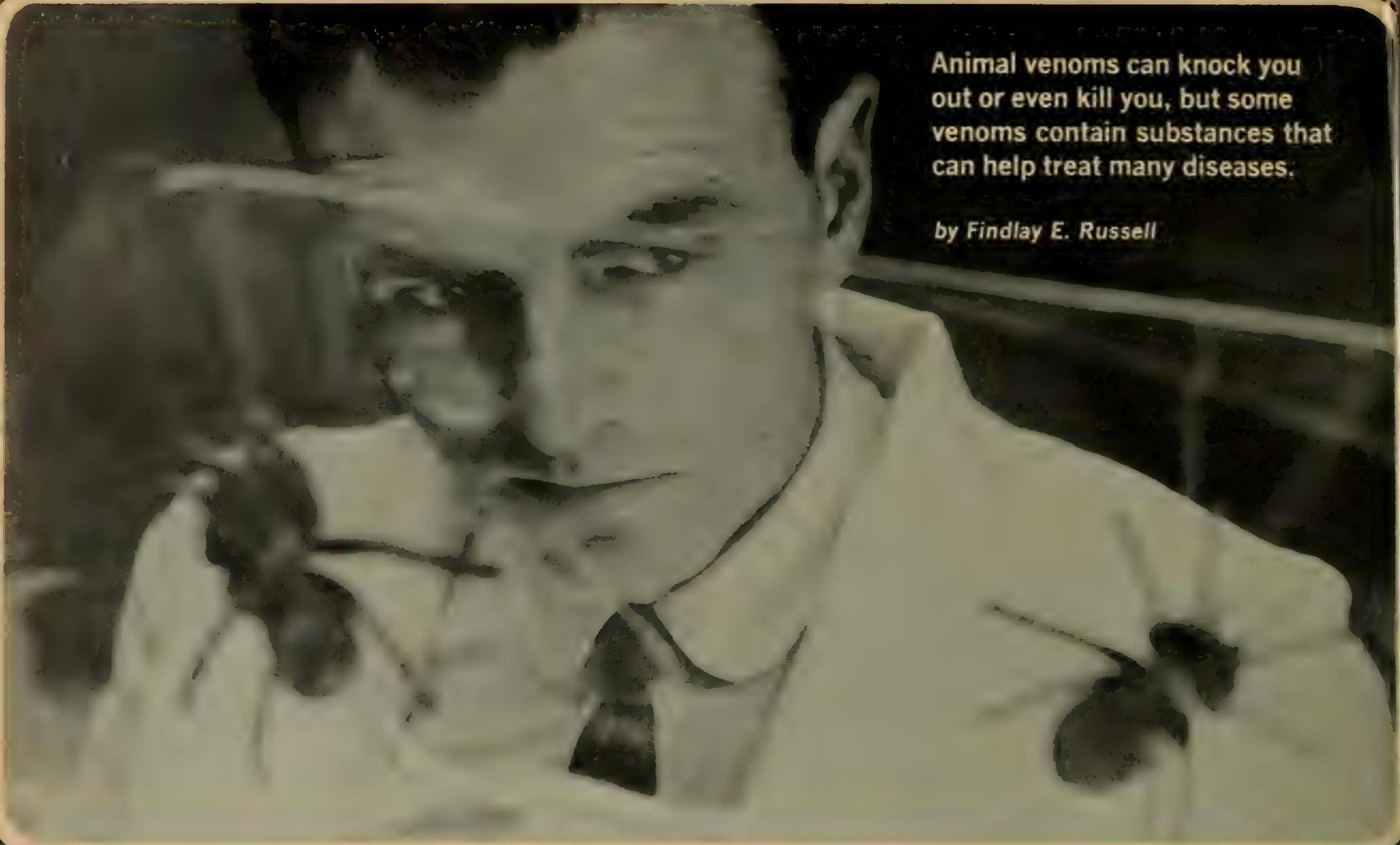
Your knee is one of many hinges in your body. (Can you think of others?) The hinged joint in your knee allows the leg to bend back and forth, but not sideways, like the joints in your hip and shoulder.

Some machines have "locks" which allow a part to move just so far and no farther. You have such a lock in your knees. When you straighten your leg, the thigh bone twists, pulling a wedge of cartilage around so that it keeps the knee from bending any farther.

Your forearm and hand are lifted by the tightening of your *biceps* muscle. When you straighten your arm the biceps muscle relaxes. The same thing happens in a power shovel. A cable is wound up to lift the "arm"; then the cable is unwound to lower it.

Your spine is like a strong spring. It is a stack of rigid bones that helps support the body. Between each two bones *(vertebrae)* is a cushion of *cartilage*. Without this springy material you would feel bumps and jolts as you walk.

POISON or MEDICINE?



Animal venoms can knock you out or even kill you, but some venoms contain substances that can help treat many diseases.

by Findlay E. Russell

The author, Dr. Findlay E. Russell, looks at some tarantulas in his laboratory.

■ How would you like to milk tarantulas eight hours a day and spend your evenings removing the venom glands from black widow spiders? And just so weekends wouldn't get dull, you could go to the beach and collect stingrays or perhaps even dive for poisonous sea urchins.

This may sound like witches' work, but it is all part of the weekly schedule for me and my staff of *venomologists* at Loma Linda University in Los Angeles. We study animal venoms—the poisons that certain kinds of animals can deliver by biting or stinging their victims. We try to find out what they are made of, how they work, and how they might be put to good uses—to treat some diseases, for example.

Our laboratory at the Los Angeles County General Hospital is one of the largest and most widely known venom laboratories in the world. In it we keep all kinds of venomous snakes, spiders, scorpions, and sea animals. Walking into our laboratory is like walking into all things "nice": snakes in jails and stingray tails; bats and mice, and spiders for spice.

"Milking" Spiders and Snakes

Each of our pets has his own cage, and pasted on the outside of each cage is a record of the *milkings,* that is, how much venom is removed from the animal. But how do you take venom from say, a spider, a scorpion, or a rattlesnake? Before being milked, each animal is given an *anesthetic,* just like a human before surgery. This dulls the animal's senses so that it can be handled, and the venom removed, without injuring the animal or the scientist. Even so, this is *not* a job for an amateur to try—it is too dangerous.

Spiders, scorpions, and centipedes are milked electrically. A small current is passed through the muscles surrounding the animal's venom glands. This causes the glands to pull together, squeezing the venom out through the fangs or the sting. The venom is collected on a strip of special paper.

Some spiders give such a small amount of venom that it cannot be seen with the eye alone. These spiders are milked under a microscope. Sometimes one has to milk 20 or 30 spiders to get a single drop of venom. The venoms of some kinds of spiders are so rare that they would cost $3,500 an ounce, if an ounce could be had. However, some scorpions give five or six drops every time they are milked.

The rattlesnakes are milked by putting pressure on both of the venom glands and forcing the venom out through the fangs, which have been pressed through a rubber sheet that covers a special collecting dish *(see photo)*. Small rattlesnakes may give no more than a drop of venom.

After an animal has been milked, the venom is dried, frozen, and stored in a deep freeze until it can be used in an experiment.

Vengeful Gods?

The study of venomous animals and their poisons has stimulated the minds and superstitions of men for many centuries. In early days the results of the bites or stings of venomous animals were often blamed on forces beyond nature. Vengeful gods were thought to be living in the animals. Even as late as the seventeenth century some people claimed that the bite of a snake contained "enraged spirits," not "poison."

Venomous kinds of animals are found in every major group except the birds. We don't know the exact number of venomous animals, but we do have some idea of the number of such kinds, or *species,* in most of the animal groups. For example, of the 2,500 or so species of snakes found throughout the world, only about 250 are dangerous to man. There are about 1,000 poisonous species of fish and other animals living in the oceans. At least 700 species of insects, spiders, and other *arthropods* are known to be venomous. There are even venomous mammals, including the male duck-billed platypus and certain kinds of shrews.

The venom of rattlesnakes flows from a gland in each cheek to an opening near the tip of the hollow fangs. Here a rattlesnake is held so that the venom drips into a glass.

There are many venomous animals in the United States. Of about 115 species of snakes, 19 are venomous, including 15 rattlesnakes, 1 copperhead, 1 cottonmouth, and 2 coral snakes. Another venomous reptile is the Gila monster, a lizard of the southwestern United States. Venomous snakes are found in every state except Hawaii, Alaska, and Maine.

Many other venomous creatures are found in our coastal waters. They include the stingrays and sculpins (scorpionfishes), some catfishes, jellyfishes, and even several kinds of sponges, segmented marine worms, and sea urchins.

Among the arthropods known to be poisonous to man are the black widow spider, the brown or violin spider, the fire ant, certain ticks, the hairy caterpillar, the tarantulas, several of the centipedes, the scorpions, and the ants, bees, wasps, and hornets. Only the black widow and brown spiders and two species of scorpions present a real threat to man, and even most of the injuries caused by these animals are rarely serious.

When we think of venomous animals, we usually think of those times when a human is bitten or stung. But this is rare. The venoms are used in other ways. In the rattlesnakes the venom is used for getting food. It enables the snake to kill its prey, and it also helps digest the food (since snakes do not chew their food). Spiders, too, use their venom in getting food. Their venom does not appear to kill the prey instantly as snake venoms often do. Instead, it usually paralyzes the prey. This permits the spider to feed at a more convenient time. However, both snakes and spiders can use their venom in self-defense when attacked by other animals or stepped on by humans.

Scorpions, for the most part, use their venom in defense, although some species may use their sting and even their venom in subduing a large insect. Stingrays and most other venomous sea animals also use their venoms as part of their defensive armament.

Putting Venoms To Work

Most venoms are complex mixtures, made of different chemical parts called *fractions*. Different fractions of an animal's venom have many different actions. Some fractions change the blood so that it cannot clot when exposed

(Continued on the next page)

to air. Other fractions clot the blood, even inside blood vessels. One fraction causes an electrical block that keeps nerve "messages" from reaching the muscles. Still another fraction causes blood pressure to rise. Some of the more important fractions cause pain, yet at least one venom fraction blocks pain.

You can probably think of some uses for these widely different properties of venoms. Today, in laboratories throughout the world, scientists are studying how these venoms work and how we humans might use them in chemistry and in the treatment of disease.

For instance, one fraction of cobra venom is used to kill pain; a fraction of scorpion venom is used to stimulate muscles; and a part of a fish venom is used to partly close blood vessels. Venoms have also been used in the treatment of hemorrhage, cancer, arthritis, tetanus, yellow fever, blackwater fever, epilepsy, heart disease, and many other diseases.

In our laboratory we have been studying how venoms produce their effects on living cells *(see photo)*. We do this by first breaking the venom down into its fractions. Then we test these fractions on animals which have been attached to special recording devices. For instance, when we study the fractions of black widow spider venom, we use a cockroach that has been connected to a special nerve recording apparatus. And when we study stingray venom we observe its effects on a nerve in the body of a lobster or crayfish. The information we get from these simple animals can often be applied to our knowledge of how these poisons work in man.

The uses for venoms in mankind's medicine chest are enormous, and during the next 10 years we shall find many ways to use these complex substances ■

How To Treat Bites and Stings

Over 580 times more people are killed by accidents in the home every year than are killed by venomous animals. And almost eight times as many people die from measles in the United States as from the bites or stings of all the snakes, spiders, scorpions, bees, and other venomous animals put together.

Nevertheless, knowing how to treat bites and stings is important. Most of the deaths from these injuries are in the untreated or mistreated cases. First, *do not panic*. There is adequate treatment for all types of bites, and they are rarely serious. Of the 6,600 cases of snakebite in the United States each year, less than 15 end fatally.

In the case of a rattlesnake bite, place a tourniquet (a tight band that slows the flow of blood) above the bite or between the bite and the heart. Leave this in place, releasing it for 90 seconds every 10 minutes. Next, make a cut with a sterile blade through both fang marks. These incisions need be no longer than ¼ inch and no deeper than just through the skin. Most rattlesnake bites penetrate no deeper than that.

Use a suction device provided in snakebite kits, or suck venom from the cut with your month *(but only if you have no cuts or sores in your mouth and no bad teeth!)* for about 30 minutes. Cutting and suction are useless if not carried out within 30 minutes of the bite. Put a splint around the injured part and keep it motionless, and take the victim to the nearest doctor for treatment.

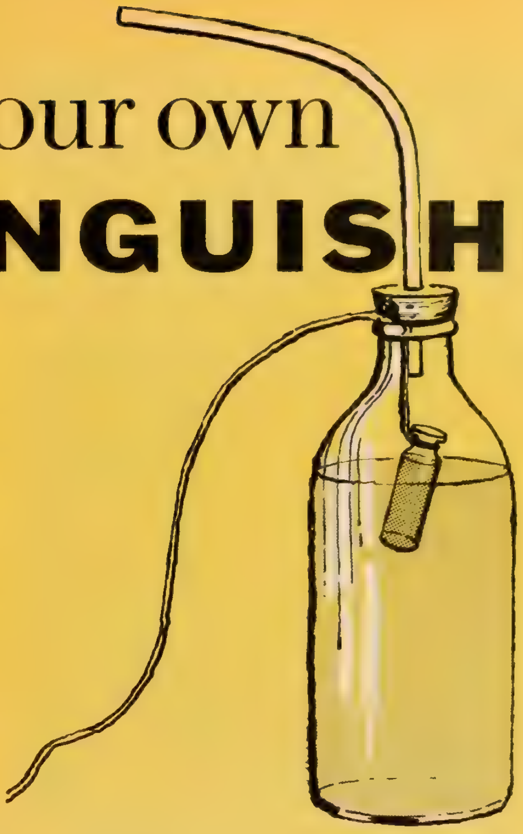
In most cases of scorpion or bee sting or spider bite, there is no special first aid treatment. An ice bag can be placed over the injury for an hour or so and a soothing cream applied. A doctor should see all victims of black widow and brown spider bites, and those stung by scorpions in Arizona, New Mexico, and Texas.

Stings by stingrays and sculpins can be treated by putting the affected part in hot water for 30 minutes to an hour immediately following the injury. Any cuts from such stings should be treated by a doctor. For jellyfish stings, pour alcohol over the wound (do not rub!), then cover it with a thin layer of dry sand or flour. After several minutes, scrape off the sand or flour with a sharp knife. In most cases this will remove the stinging cells that have penetrated the skin.

Dr. Russell uses this apparatus to study the effects of venoms on living cells. A nerve and muscle from a guinea pig are suspended in a special "bath." When venom from cobras is put into the bath, it blocks "messages" between the nerve and muscle. Dr. Russell then puts other substances into the bath to see if he can prevent the block caused by the cobra venom.

How to make your own
FIRE EXTINGUISHER

by Steven Morris



■ Stir some baking soda (other names for it are bicarbonate of soda and sodium bicarbonate) into a glass half filled with water. Keep adding baking soda little by little until no more will dissolve. Now pour a teaspoon of vinegar into the glass. What happens?

Does it make any difference if the vinegar is added to the water before you stir in the bicarbonate of soda? Try it and see, using a clean glass.

The bubbles that you see are bubbles of a gas called *carbon dioxide*–the same gas that makes soda pop bubbly. This gas is made when bicarbonate of soda combines with an acid, and vinegar is a mixture of water and a weak acid called *acetic acid*.

WHAT MAKES YOU BURP?

Has your mother ever given you bicarbonate of soda to drink when you had an upset stomach? Upset stomachs are sometimes caused when there is too much acid in your stomach. (The acids in your stomach help to digest the food you eat.) Can you figure out what makes you "burp" when you drink bicarbonate of soda and water?

MATERIALS YOU WILL NEED

A pint bottle with a wide mouth (*see diagram*). ● A cork or rubber stopper that fits the bottle, and has a hole through it. ● Plastic tubing that fits through the hole in the stopper. ● A small pill bottle that can fit easily through the neck of the bottle. ● String about a foot long. ● Water, vinegar, bicarbonate of soda.

This combination of soda, acid, and water is what makes a common kind of fire extinguisher–the *soda-acid* fire extinguisher–work. (Some of the fire extinguishers in your school may be this type; read the labels and see.) When soda and acid are mixed together in this kind of fire extinguisher, the bubbles of gas push the water out of a hose and onto the fire.

Making the Extinguisher

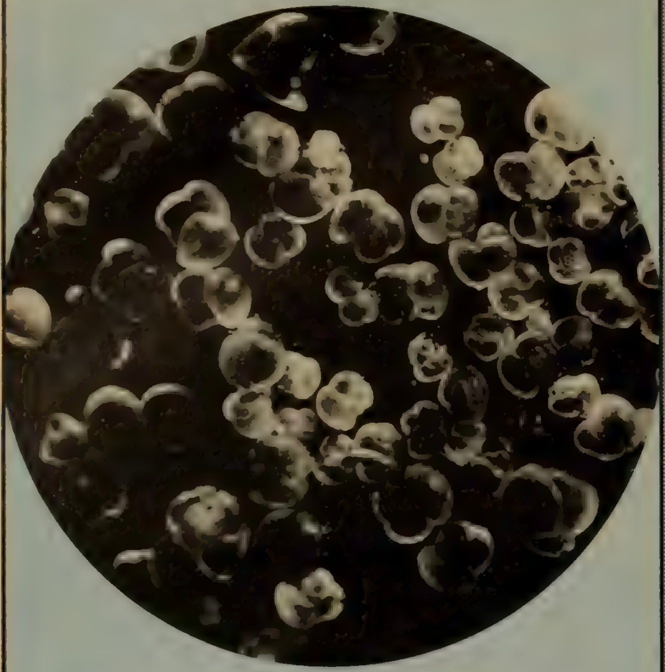
You can use the simple materials listed on this page to make your own soda-acid fire extinguisher. The bottle should be about three-quarters full of water. Put in three teaspoons of bicarbonate of soda and stir until the soda has all dissolved in the water.

Push the plastic tubing through the hole in the stopper so that the tubing sticks down into the bottle about an inch or so (*see diagram*). The end of the tube that comes out of the top of the stopper will be your "hose," so it should be 10 inches or so long. Unless the tubing fits snugly into the stopper, the fire extinguisher will not work well. To get a snug fit, you can drip some candle wax all around the tube at the top and bottom of the stopper.

Next, tie the end of the string around the neck of the pill bottle, and fill the pill bottle with vinegar–but don't fill it to the top! Holding on to the string, dangle the pill bottle into the pint bottle so that most of the pill bottle is in the water, but the top is above the water (*see diagram*).

Now carefully put the stopper in the bottle neck. It should be tight so it will keep the string from slipping; also to keep water from leaking out around the stopper. Point the "hose" toward a sink and turn your fire extinguisher upside down so the vinegar mixes with the water and bicarbonate of soda. What happens?

Fill up the extinguisher two more times. The first time use the same amount of vinegar but only a little baking soda. What happens when you turn the extinguisher upside down? Now try it using three teaspoons of baking soda but only a little vinegar. Keep trying different amounts of vinegar and bicarbonate of soda until you find the amounts that produce the strongest stream of water ■



The forams shown in this photomicrograph are about 10 times their actual size.

Tattle-tale Sea Shells

by David Linton

By comparing tiny sea animals grown in the laboratory with shells of the animals' ancestors, scientists are finding out much about how the earth's climate has changed over hundreds of millions of years.

When someone mentions the word "fossil," do you think of the huge skeletons of dinosaurs that you see in museums? Like other fossils, the remains of dinosaurs are important because they tell us something about what our world was like when those animals lived, many millions of years ago.

Dinosaur fossils are not the only kind, though. There are fossils of plants and many other kinds of animals. Some of the animal fossils are so small that they can be seen only under a microscope. These tiny fossils are the shells of animals that lived in the sea long, long ago.

Scientists do not have to search in the sea to find these fossils. They can find them on dry land. Much of what is now land was under water at one time or another in the earth's history. For example, 500 million years ago much of the United States, Europe, and Asia was covered by shallow seas. The little shells help us to find out more about those times—hundreds of millions of years ago, long before the dinosaurs lived.

Drilling for "Forams"

Among the many kinds of tiny fossils are some called *foraminifera*. Scientists call them "forams" for short. Unlike the dinosaurs, these tiny animals did not all become *extinct,* or die out. They live in great numbers in the sea today.

Foram shells are shaped somewhat like snail shells, but much smaller. Long, long ago, billions upon billions of these shells drifted downward, piling up on the bottom of the sea as the animals died. (The same thing is happening today.) Then when certain parts of the sea floor were pushed upward by changes in the earth's crust, these layers of shells were exposed to the air as limestone rock. The famous White Cliffs of Dover, in England, are made of these shells. So are the great limestone blocks that the Egyptians used to build their pyramids.

There have been forams living on the earth for about 500 million years. Some of the kinds that live today have been around for 50 or 60 million years. Although most of the forams we know are tiny, one kind that died out long ago was six inches across. The largest ones living today are smaller than a grain of sand. With a strong magnifying glass or a low-power microscope, you can see their shells *(see photo).*

The microscopic forams are the ones that scientists study most. It is because they are so tiny that scientists can get them in perfect condition from far beneath the earth's surface. If a large fossil like that of a dinosaur were buried hundreds of feet under the ground, it would be difficult for scientists to find it or dig it out without breaking it. The tiny fossil shells of forams, however are found in rock brought up by drills from far down in the earth, and from the sea floor. Larger fossils are ground up by the drill, but the tiny forams are unharmed.

From the amount and kinds of rocks that a fossil foram was buried under, scientists can get a good idea of how long ago the animal lived. And the thickness of the layer of rock in which the fossil is found is a clue to how long the area was covered by sea water. Also, like most other animals, forams have changed over the millions of years since they first appeared. Some kinds of forams changed in ways that did not enable them to survive for long periods in the earth's history. Because we know when some of these kinds of forams lived and died out, their fossil remains can also be used as a clue to the age of rocks in which they are found.

There are many different kinds of fossil forams. Some lived in cold waters, others in warm tropical seas. Some lived in shallow water, some in the deep ocean. Some floated near the surface of the sea, others lived on the bottom. When scientists find their shells they can tell a great deal about the waters in which those forams lived.

Suppose you are examining some limestone brought up from underground in Oklahoma. You find the shells of a foram that lived a million years ago. You also know that the foram lived only in warm, shallow water. You can be pretty sure that that part of Oklahoma was covered by a warm, shallow sea a million years ago.

It is in warm, shallow seas that we find the billions of tiny plants and animals whose remains can be turned into oil by great heat and pressure under the earth. Actually, not just Oklahoma but the whole central part of North America and the northeastern part of South America have been covered by such seas. That is why we find oil in Alberta, Canada; in Texas; and in Venezuela.

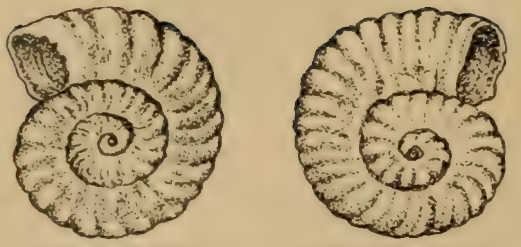
Studying Living Forams

About 50 years ago there were very few scientists studying forams. Then it was discovered that foram shells could be used in finding oil. Soon hundreds of scientists began studying forams, and they needed a system for classifying and identifying them. In 1928 Dr. Brooks F. Ellis of The American Museum of Natural History, in New York City, started a project that is still far from finished—a catalog of forams that lists and describes every known kind of foram. The catalog now has 65 volumes listing 28,000 different kinds of forams! New ones are still being discovered fast enough to fill three more volumes every two years.

Then some biologists who were studying living forams made an interesting discovery. They found that the same kinds of forams would develop differently under different

(Continued on the next page)

This scientist is splitting a core, or sample of the sea bottom which is obtained by driving a metal pipe into the bottom, then lifting it to a ship and pushing out the rock, clay, and other sediments trapped in the pipe. The core that is shown contains many tiny foram shells that drifted to the bottom over a period of 10,000 years or so. From the kinds of shells and their location in the core, scientists can figure out when the forams lived and something about the temperature of the sea water at that time.



One kind of foram makes left-coiling shells if they live in cold water and right-coiling shells if they live in warm water. So far, no one knows why.

Tattle-tale Sea Shells (continued)

living conditions. Sometimes they developed so differently that they did not even look like the same animal. For example, some forams have a spiral shell somewhat like the shell of a snail. Sometimes the shells coil to the left, other times to the right. Scientists have discovered that one kind of foram makes left-coiling shells if it lives in cold water, but right-coiling shells if it lives in warm water. No one knows why. But when we find these shells we can now tell whether the water was warm or cold when the forams were alive.

Because of these discoveries, the scientists who study fossil shells began to wonder whether their 28,000 kinds of forams were really all different. Perhaps, they thought, some of them were the same animals living under different conditions. So they asked biologists to help them by studying living forams.

One of these biologists is Dr. John J. Lee, also of The American Museum of Natural History. Dr. Lee has aquariums in which the water rises and falls just as the ocean tides do. The temperatures, pressure, and saltiness of the water can be precisely controlled. Dr. Lee and the scientists who work with him, Dr. Hugo D. Freudenthal and Dr. Stanley Pierce, are trying to learn all they can about how forams live and how changes in their living conditions affect the forams.

Forams are not hard to find. They can be collected along any seashore. But to study them thoroughly you have to find out how to keep them alive and get them to reproduce in the laboratory. This can be very difficult. Though a number of scientists had observed living forams, at the beginning of Dr. Lee's study no one knew exactly what the animals eat. Dr. Lee had to find out what to feed them. Temperature was another problem. All the forams of one kind that had lived for years in the laboratory were lost in a single day. The laboratory's air conditioner broke down and the temperature went too high. So far, Dr. Lee has not found any more forams of that kind.

Less than 25 kinds of forams have been successfully grown in the laboratory, but already the biologists have made some important discoveries. They have found that forams can change in shape and appearance from eating a different kind of food. They have also found clear differences between forams that live near the surface of the sea and those that live on the bottom.

The study of forams has already led to a startling discovery by scientists at Columbia University's Lamont Geological Observatory at Palisades, New York. They studied fossil forams taken from the ocean floor. By identifying the different kinds that live in cold and warm water, they have been able to learn a lot about the climate of the past. Their study shows that the first ice age began about 1.5 million years ago. This is half a million years earlier than scientists thought before. The discovery changes the time scale of the past—especially for man. Scientists believe that the evolution of modern man occurred largely after the beginning of the ice ages, and that date has now been moved back 500,000 years ■

Studying forams is a "down-to-earth" job. Dr. Lee is shown examining some that he collected from the sea off Long Island, New York.

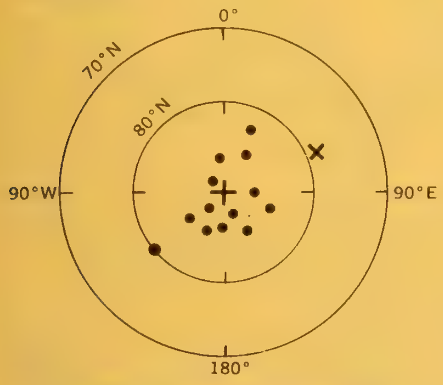
Using This Issue . . .

(Continued from page 2T)

We know that about 10 times as much heat from inside the earth is rising through the mid-Atlantic rift as through the normal sea bottom, and 10 times as much through the normal sea bottom as through the deep-sea trenches. But this does not necessarily mean that there are convection currents in the material beneath the earth's crust. This idea, like that of continental drift, is still just a theory.

Topics for Class Discussion

- *Will we ever know for sure if the theory of continental drift is correct?* Possibly yes, possibly no. But most important scientific discoveries come through attempts to prove or disprove a theory, so efforts to solve this mystery may be fruitful even if the question is never completely answered.
- *Are the earth's magnetic poles still moving?* Yes. Magnetic measurements of earth material formed over the past million years or so show that the Magnetic North Pole has been in a number of different locations during that period—all of them clustered around the Geographic North Pole *(see diagram).*



+ Position of Geographic North Pole

× Present position of Magnetic North Pole

● Positions of Magnetic North Pole during past million years or so

10 Poison

Every kind of animal must have some means of food-getting and defense. In this article, Dr. Russell tells about certain animals that meet these needs with venom, and how venom can be useful in human medicine.

Topics for Class Discussion

- *What medicinal uses can you think of for animal venoms?* Fractions that cause clotting can be used during operations to reduce blood loss. A fraction of cobra venom controls pain more effectively than drugs and is not habit-forming.
- *Are bee stings dangerous?* Yes. Each year in the United States more people die from bee stings than from snake bites. Some people are more sensitive to stings than others. A single sting sends some individuals into severe shock that may result in death.

A bee's sting is tipped with small barbs that prevent it from being withdrawn. After inserting the sting, the bee tries to fly away and usually rips off the end of its abdomen. The bee dies from this injury, but its sting stays behind, still pumping venom into its victim.

- Do you suppose that anyone really knows the best way to treat a bite or sting from a venomous animal? Treatments are available for all kinds of such injuries, but there has been little opportunity to discover the *best* way. Such injuries are rare, so no one doctor has had much experience in treating them.

This situation is related to the discussion of the "Seeds & Salt" article. You can learn a lot more about pea seeds by testing 20 than by testing one. In the same way, large numbers of snakebite cases must be studied before an ideal treatment is found.

N&S REVIEWS . . . *(continued from page 1T)*

preceded all the big ones. The story is told from the finding of the first few bones in a ledge in New Mexico to the final exhibit at The American Museum of Natural History in New York City. The work of the paleontologist in the field is clearly explained and the text is supplemented with drawings, diagrams and actual photographs of the work in progress. A book to appeal to all dinosaur enthusiasts from fourth grade up, and a real inspiration to future paleontologists.

First Book of Fishes, by Jeanne Bendick (Franklin Watts, Inc., 72 pp. $2.65), could be used as a reference book at the fifth grade level. Miss Bendick has simplified a complex subject, employing a minimum number of misleading broad statements – those ever-present pitfalls for anyone trying to simplify anything. One wishes the illustrations reflected the same care, but they have a slap-dash quality ill-suited to a text that deserved clear, accurate drawings.

The Phantom World of the Octopus and Squid, by Joseph J. Cook and William L. Wisner (Dodd, Mead and Co., 96 pp. $3.25). Anything written about these animals runs the risk of being called sensational. The very nature of these animals seems to call forth a big-eyed breathless approach. However, although the authors indulge in re-telling myths, folklore, and ancient accounts, the bulk of the book is devoted to our modern knowledge of these fascinating animals. Illustrated with many photographs and a few drawings and prints. Sixth grade and up.

Our Fellow Immigrants, by Robert Froman (David McKay Co., Inc., 118 pp. $3.50). A lively book on the domestic animals, rats, fish, birds, plants, and insects man has been bringing to this country since the days of the explorers, and what has happened to them since. The complexity of man's relationship to his environment is shown in the way some of the resulting problems were solved. Sharp lessons in ecology are hidden in the stories of some of these "immigrants." Well researched and a good book for junior high students.

Moon Moth, by Carleen Maley Hutchins (Coward-McCann, Inc., 48 pp. $2.75), is a beautiful book, both in its text and its illustrations. In a well-paced narrative form, scientific facts are presented with charm and skill. Using words easy enough for a fourth-grader (a short glossary takes care of the few necessary long words), the author tells the luna moth's life-story. Contains a bibliography, plus notes and references.

Never Pet a Porcupine, by George Laycock (W. W. Norton and Co., Inc., 167 pp. $3.50). As its title suggests, this is a breezy, humorous book by an author who knows how to entertain. It is also an excellent, informal guide to an assortment of 22 common animals including the weasel, crow, beaver, earthworm, and ladybug. Each

(Continued on page 4T)

N&S REVIEWS...

(continued from page 3T)

is illustrated with a full-page photograph. Even children who dislike reading should enjoy this one. Although the jacket says 8-12, it would take a fifth or sixth-grader to read this by himself.

Animal Teeth, by George F. Mason (William Morrow and Co., 96 pp. $2.75). This latest book in the author's excellent series should be especially valuable to the aspiring mammalogist. The teeth of representative mammals of many groups are carefully analyzed and illustrated. There is a dentition chart in the back and a vocabulary. Teeth of fish and reptiles—especially snakes—are also described. A highly readable, graphic book containing information not easy to find.

The Big Cats, by Desmond Morris; **Animals of the Arctic**, by Gwynne Vevers; and **The Curious World of Snakes,** by Alfred Leutscher (McGraw-Hill Book Co., each 32 pp. $2.95). These three are part of the McGraw-Hill Natural Science Picture Books series. They do have large illustrations and a horizontal, picture-book format, but the text, though brief, is not written for very young children. Such phrases as, "an experienced eye can also detect other minor distinctions," would take a bit of doing for even the average fifth grader. These are British books and so, to us, there are a few oddities. Our garter snake is compared in size with the common British grass snake, and shedding is referred to as sloughing (pronounced "sluffing"). However, these are attractive books, uniformly well illustrated and good introductions to their subjects.

The Surprising Kangaroos and Other Pouched Mammals, by Patricia Lauber (Random House, 81 pp. $1.95). This is a good survey of the marsupial mammals for the elementary school child. A great deal of material has been gathered together which would be difficult for a child to find elsewhere. It is presented in readable fashion and well illustrated with good photographs. Many of the animals pictured will probably be brand new to most children. It may arouse their curiosity to learn more.

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nature and science

TEACHER'S EDITION

VOL. 3 NO. 13 / MARCH 21, 1966 / SECTION 1 OF TWO SECTIONS

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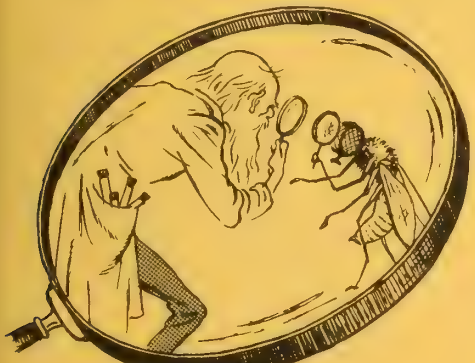
What Makes a Scientist Run?

by Vincent G. Dethier

■ By the rules of the game, Science is supposed to be objective. This is, of course, ridiculous. As long as Science is conducted by scientists it will be subjective. There is a basic law of physics which states that in one way or another the observer always affects what he observes. This effect may be infinitesimally minute or beyond all hope of measurement or it may be apparent to any dullard. But clearly between the fly and the scientist there is an interaction.



What the scientist does to the fly determines in part what the fly does, and what the fly does is seen by the eyes of the scientist and sends nerve messages along his optic nerves to his brain and is there switched around and juggled and changed and eventually comes out as a thoroughly subjective observation. So, perhaps to know the fly one must also know the scientist.

This article was adapted from To Know a Fly, *by Vincent G. Dethier, © copyright 1962 by Holden-Day, Inc., San Francisco ($3.75; paperback $1.95), and is printed by permission of the publisher. (See also "How Does a Fly Say No?",* N&S, *Oct. 4, 1965, p. 1T.) Dr. Dethier is a Professor of Zoology and Psychology at the University of Pennsylvania.*

Scientist (Homo Sapiens)

Strange as it may appear to the layman, the scientist is, above all, a human being. He is as inconspicuous in a crowd as a mythical Martian come to earth in human form. He has a wife and children whom he treats no better or no worse than anyone else. He experiences happiness and unhappiness like anyone else, and he gets sick and dies—like anyone else.

Outside his science he is not inevitably smarter than everyone else. If anything, he has a modicum less horse-sense than the average man on the street. In politics he may be incredibly naive. But he probably spends a greater period of his life preparing for his career and works longer and harder at it, at a lower salary (at least in the academic world) than many of his fellow men.

Since he spends nearly as much time in his laboratory as do his own experimental animals, he tends to acquire certain amenities. The average laboratory invariably has the makings of tea or coffee. There is at least one comfortable, not infrequently ancient, chair. And some favorite art form usually decorates the walls. These objets d'art may range all the way from a sample of reverse appliqué made by the San Blas Indians to a genuine Pollock.

The central figure in this comfortable atmosphere works either in his shirt sleeves or in a lab coat. The lab coat has acquired the rank of a status symbol in the minds of the public, shiny new Ph.D.'s, and some of the older, more insecure Ph.D.'s. On the other hand, working in a laboratory is dirty and occasionally highly destructive to clothing as anyone who has had the seat of his pants burned out by acid will attest.

(Continued on page 3T)

nature and science

IN THIS ISSUE

(For classroom use of articles preceded by ●, see pages 2T and 3T.)

● A Bird Worth a Forest Fire?

A rare warbler is adapted to life in a special environment that is brought about by forest fires.

The Walls That Killed

Scientists worked for more than 100 years to discover how the combination of a mold and damp wallpaper led to the deaths of a number of persons.

● Onward and Upward

You can use this introduction to the inclined plane, wedge, and screw to help pupils discover the concepts of mechanical advantage and work.

● Trees That Make Land

A picture story shows how mangroves are adapted to spread through the tropics, making land where they grow.

Do You Ever See Double?

These projects will help your pupils understand better the way that their eyes see depth.

● Just Call me . . .

Your pupils can find out why each person should know his own blood type; also how other blood factors can be used to identify individuals.

IN THE NEXT ISSUE

A special-topic issue on Exploring the Weather: The biography of a thunderstorm . . . How to make your own weather station . . . Investigating the weather in your own area . . . Where do the winds come from? . . . How true are weather "sayings"? . . . New techniques for predicting weather.

USING THIS ISSUE OF NATURE AND SCIENCE IN YOUR CLASSROOM

PAGE 2 A Bird Worth

Each kind of plant and animal is adapted to survive in its environment. Some are more highly specialized than others, and it is these organisms that are most vulnerable to changes in their environment. Thus the Kirtland's warbler was in trouble when modern fire control methods broke the cycle of forest fires in the jack pine forests of Michigan.

The Kirtland's warbler is one of 42 species of wood warblers that nest in the United States and Canada. All migrate south, spending the winter in the warm tropics where insects are plentiful. Wood warblers are found only in the New World, from Alaska to Argentina, and are not closely related to the Old World warblers of Europe, Asia, and Africa.

Activities

- This article introduces the idea of *plant succession*. Starting with bare soil, there is a series of changes in plant life that leads to the *climax community* of your area—a certain kind of forest or perhaps a prairie. The ideal nesting site for the Kirtland's warbler is a temporary stage in the plant succession that leads to a forest. The diagram on this page shows some of the stages in the plant succession leading to a forest community.

Have your pupils study the plant succession that occurs on the land in your area. They can find examples of different stages in nearby parks or other undeveloped land. Have them notice what kinds of mammals and birds are associated with the different stages of succession. Their findings can be presented in a bulletin board display.

- Investigate the status of animals that are threatened with extinction. Find out what species are in danger, and why. What can be done to save them? Is it important to save them? A team of pupils can be assigned to gather information on a particular animal. Possible references include: *National Wildlife* and *Audubon* magazines; a wildlife biologist from your state conservation department; a naturalist from a nearby park or nature center.

PAGE 8 Onward and Upward

This introduction to the inclined plane makes a good takeoff point for classroom investigations that will help your pupils discover the concepts of *mechanical advantage* and *work*.

For this purpose, your pupils will need to use a spring scale, rather than a rubber band, so they can measure the pounds of force needed to lift an object from the floor to the top of a stack of books, with and without an inclined plane. They will also need boards of several different lengths, say 3, 4, and 5 feet long.

A toy truck or a roller skate is a good weight to use because the wheels minimize the friction on the inclined plane. You might tie several books to the skate to make it heavier. This facilitates measuring differences in pounds of "pull" with the scale.

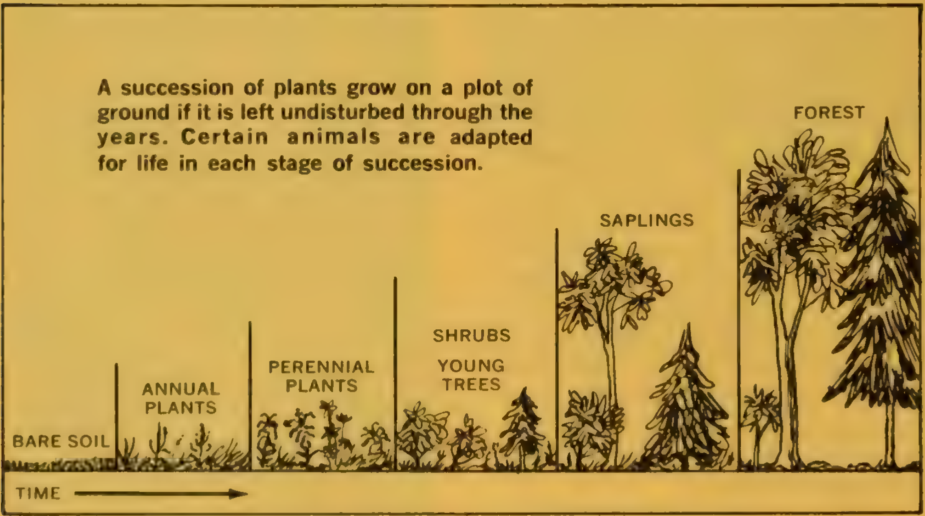
Suggestions for Classroom Use

After your pupils have found that it takes less "pull", or force, to lift an object up an inclined plane than to lift it straight up (using either the rubber band or spring scale), ask them this question: *Do you have to do as much work to lift the skate to the top of the stack on the inclined plane as you do to lift it straight up?* Explain that the laws of mechanics define work as the product of *force* multiplied by *distance*. That is, if you lift a 2-pound object 3 feet, you have done 6 *foot-pounds* of work.

Have them multiply the *pounds of force* measured on the scale as they lift the skate straight up, *times* the *distance in feet* from the bottom to the top of the book stack. Then have them multiply the pounds of force measured on the scale as they pull the skate up the ramp, times the distance in feet from the bottom to the top of the ramp. The two products should be *about* equal, indicating that it takes about the same number of foot-pounds of work to lift the skate either way.

But lifting via the ramp probably took slightly *more* foot-pounds of work than lifting straight up. Ask your pupils to guess why. Then turn the skate and books over so that the books are resting on the ramp and see how many pounds of force it takes to pull it up the ramp. This should help your pupils to see that even when the weight is riding on wheels, there is some friction between them and the board that makes it more work to pull the weight up the ramp than to lift it

(Continued on page 3T)


A succession of plants grow on a plot of ground if it is left undisturbed through the years. Certain animals are adapted for life in each stage of succession.

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nature and science

VOL. 3 NO. 13 / MARCH 21, 1966

Why were people dying of arsenic poisoning in old houses with leaky roofs and stained wallpaper?

see page 5

THE WALLS THAT KILLED

BURN
A
FOREST
TO SAVE
A BIRD?

SEE PAGE 2

nature
and
science
VOL. 3 NO. 13 / MARCH 21, 1966

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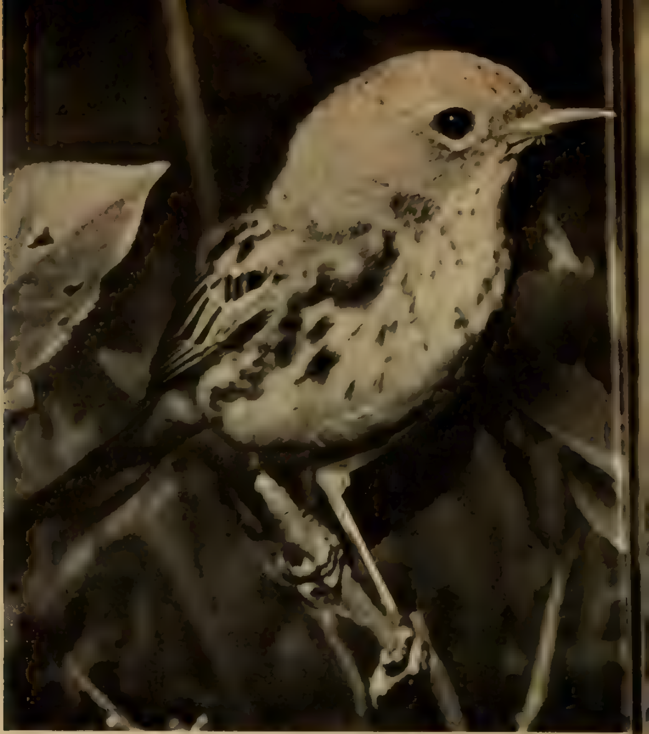


A BIRD WO

■ Wood warblers are among the smallest, most numero
and most beautiful songbirds in North America. In fa
the famous naturalist Roger Tory Peterson has call
them "the butterflies of the bird world."

This is the story of one of the rarest and most famo
wood warblers—the Kirtland's warbler *(see photo)*. It i
lemon-breasted little songster that nests only in a sm
part of one state, Michigan, and nowhere else in t
world. And even then, you can find it living only amo
certain pine trees that grow on wind-swept, sandy plai
known as the barrens. These lonely lands, scorched
the summer sun, are dry and desolate and show the sca
of terrible forest fires of the past.

The warbler's name honors a noted Ohio scientist
early days, Dr. Jared P. Kirtland. It was on his farm ne
Cleveland, on May 13, 1851, that the first specimen
this warbler was collected.

Today, 115 years later, the Kirtland's warbler h
probably attracted more attention than any other son
bird in history. In its behalf, a spectacular forest fire w
intentionally started in a national forest. A monume
has been erected in its honor. Large tracts of land ha
been set aside as Kirtland's warbler preserves. And t
Michigan State Legislature has hotly debated wheth
the robin or this warbler would make the best state bir

Thirty Pounds of Warblers

Why all this fuss? Why are people so interested in th
tiny half-ounce creature? The main reason: All of t

Yes, if the forest fire helps create a place to live for one of the rarest birds in North America.

TH A FOREST FIRE?

by Les Line

Kirtland's warblers in existence would hardly weigh 30 ounds. Less than 1,000 of these birds exist, according o counts made by people from the Michigan Audubon Society. The United States Department of the Interior lists the Kirtland's warbler among the nation's endangered vildlife, along with the whooping crane, grizzly bear, California condor, and others.

Conservationists are trying to keep these rare animals rom dying out. They have a good chance of saving the Kirtland's warbler. The key is fire, and the lock it opens s the cone of the jack pine.

What does this mean? To explain, we must go back bout 60 years, to the first discovery of a nest of the Kirtland's warbler. The warbler was a real mystery to *rnithologists* (scientists who study birds) for more than half-century. Until 1903, no one knew where it nested. The first clue came when two trout fishermen, one a young rnithologist, heard a strange bird singing near Michigan's Au Sable River. The fishermen shot one of these birds nd took it to Norman A. Wood, ornithologist at the University of Michigan.

Wood recognized the bird and rushed north by train to earch for the nesting grounds of the Kirtland's warbler. He hunted for eight days, by rowboat, horse and buggy, nd on foot, listening for the warbler's song. The Kirtland's varbler has a loud, clear voice which Wood considered "the most beautiful of all warblers." You can hear it a quarter-mile away on a quiet morning. That "ringing, iquid" burst of music finally led Wood to the long-sought nest.

It was soon learned that the Kirtland's warbler builds its nest on the ground and only in stands of small jack pine trees that cover at least 80 acres. The soil must drain quickly after a rain. The trees must be between six and 18 feet tall, eight to 20 years old, and they must have living lower branches that reach down to shrubbery on the ground. There must be openings among the pines so sunlight can reach the bottom limbs, keeping them alive.

With special needs like these it is no wonder that the Kirtland's warbler is rare. It has been found nesting only in Michigan, in an area that stretches 85 miles from

(Continued on the next page)

Kirtland's warblers build their nests on the ground. This nest contains four warbler eggs and the larger egg of a cowbird. Cowbirds never raise their own young.

north to south and 100 miles from east to west. Also, "ideal" nesting conditions are only a temporary stage in the forests of this area. As the jack pines grow bigger, the openings disappear. In a few years the land is no longer suitable for the warbler's nests.

Needed: More Forest Fires

Strangely enough, forest fires are needed to create the right conditions for Kirtland's warbler nesting areas. To understand this, you must look at the cone of the jack pine *(see photo).* Inside are 80 to 100 tiny, winged seeds from which seedlings could sprout. But jack pine cones are unusually tight, and they may lie closed on the ground or even high on branches for years without releasing their seeds. Intense heat is needed to pop the cones open and scatter the seeds.

Once, raging fires on these plains kept the Kirtland's warbler well supplied with nesting sites. Before lumberjacks stripped the land of its tall white and red pines, lightning started fires which burned for days and weeks until put out by rain. Later, the loggers left *slashings*—tops and branches of trees—which were highly flammable. The slashings fed the terrible fires which blackened hundreds of thousands of acres year after year, wiping out entire towns and taking many lives.

Today, it is a "bad" year in Michigan when more than 5,000 acres are burned across the entire state. So the Michigan Conservation Department, the United States Forest Service, and groups like the Michigan Audubon Society joined forces to help save the Kirtland's warbler. They hope to provide an everlasting supply of jack pines of the right size in the right place at the right time.

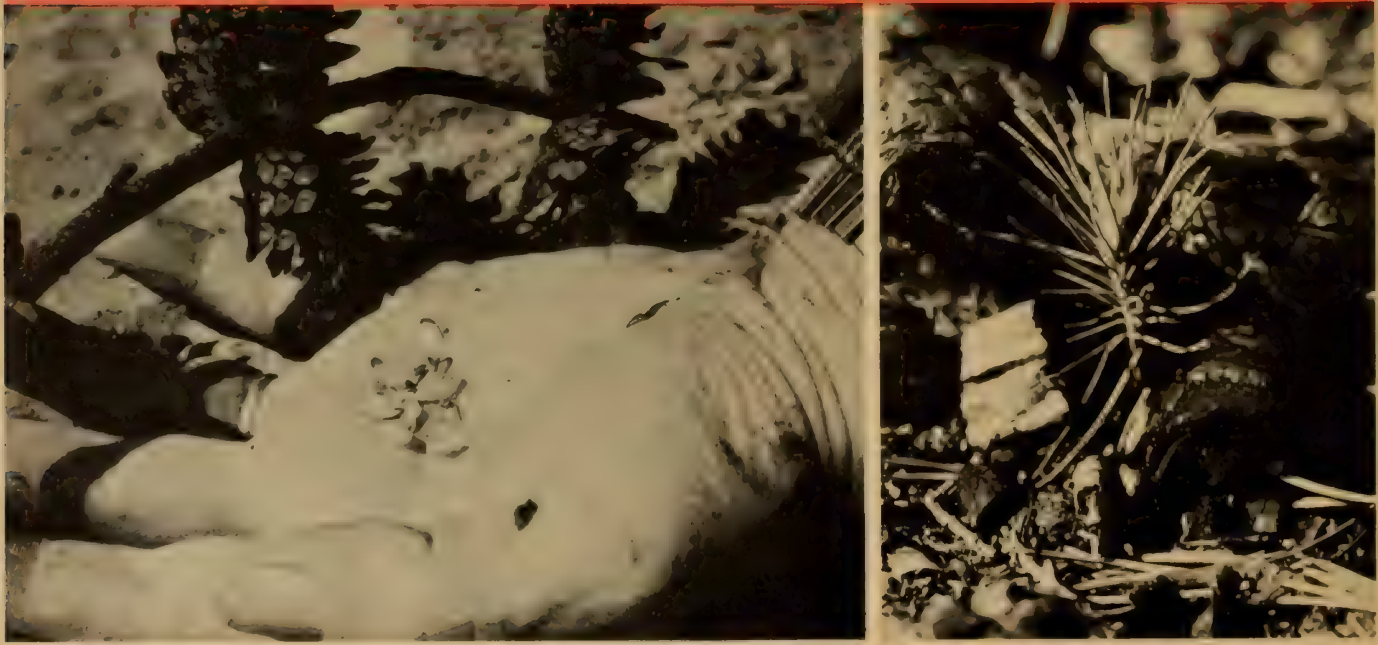
More than 17 square miles of jack pine country is being managed just for the Kirtland's warbler. Two different techniques are used. When forestry crews cut mature pines on state lands, they plant widely spaced rows of seedlings that will grow to be ideal nesting areas for the warblers.

The United States Forest Service, meanwhile, has chosen fire to do the same job. Every three to five years, a square-mile section of too-tall jack pines will be set ablaze. First, however, lumbermen cut many of the pines. They are made into paper at a paper mill. Some trees are left standing as seed trees. Limbs from the cut pines provide plenty of slash to help burn the remaining forest.

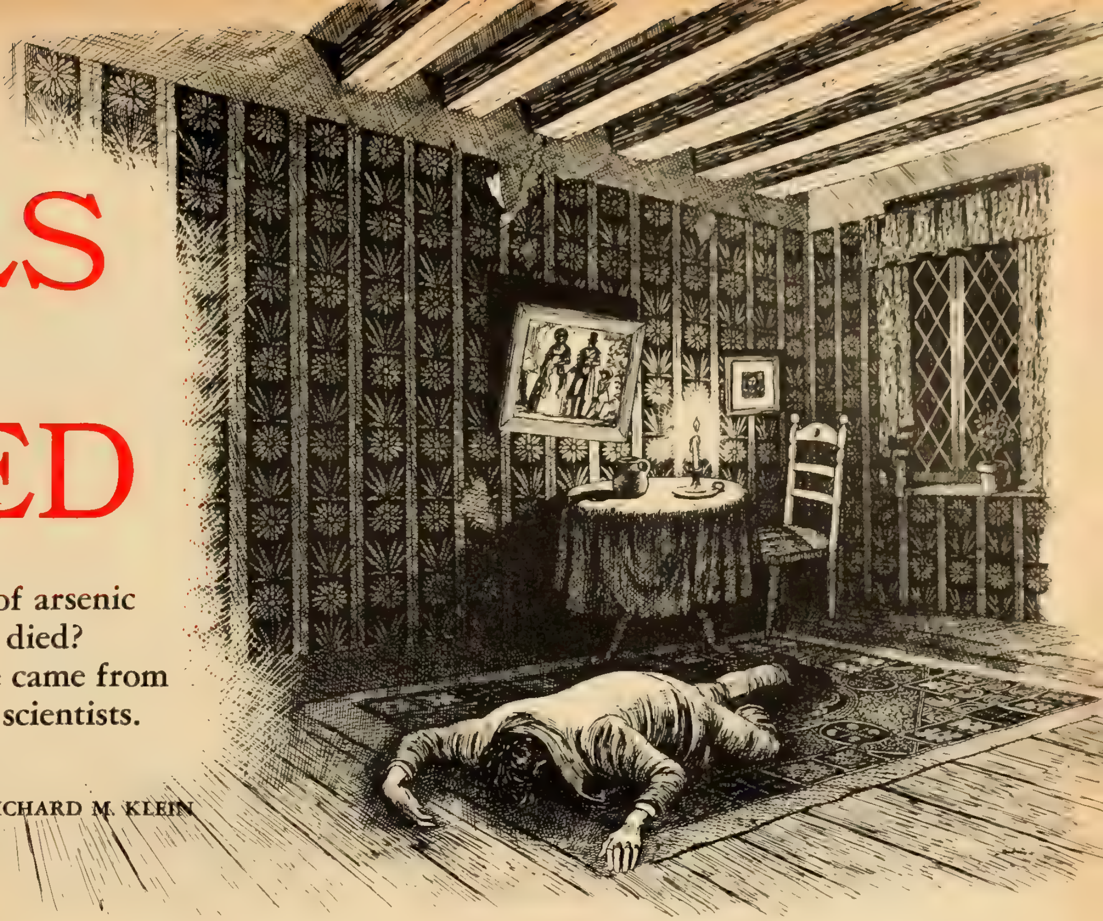
The weather must be just right for these forest fires. The wind speed and direction, the temperature, humidity, and the number of days since the last rain must all be considered. The flames must be kept from spreading beyond plowed fire lanes. The fire must also be hot enough to pop the cones of the jack pines.

The first of these special forest fires was set in early 1964. Already jack pine seedlings are pushing skyward through a carpet of blueberry and trailing arbutus. Within five to 10 years, Kirtland's warblers will be back singing and raising their young among the young pine trees ■

When the heat of a forest fire pops open the cones of jack pines, tiny winged seeds fall out. The seeds soon sprout and young trees begin to grow among the charred wood left from the fire.



The WALLS that KILLED



Two children were dead of arsenic poisoning. Why had they died? The answer to this puzzle came from a century of sleuthing by scientists.

BY
BERNARD A. WEISBERGER AND RICHARD M. KLEIN

■ In the late autumn of 1931, Mr. R. H. Ellis, who investigated deaths in the city and county of Gloucester, England, was called to a small cottage in the district called Forest of Dean. He was to examine the dead bodies of two children: an eight-year-old boy and the boy's sister, who was almost 10. Both children had been sick for several months and it looked as if they might have been poisoned.

Mr. Ellis found that each body contained enough arsenic to have killed five or six people. However, from his investigation, Mr. Ellis decided that neither the parents of the children nor any of the neighbors had poisoned the boy and girl. He found that both parents also had arsenic in their bodies, and that other relatives showed signs of arsenic poisoning. The local minister, his wife, and several other neighbors were also sick. It looked as if all of these people had taken in rather large amounts of this poison. Where could it have come from?

Mr. Ellis remembered reading reports of similar cases. Before calling the police and Scotland Yard, he decided that he might be able to solve the case. He visited all of the homes in the neighborhood, and found that the houses were very old. They all had leaky roofs. The walls in the children's rooms were slightly damp and the wallpaper was faded and stained.

Mr. Ellis peeled off strips of the paper and took them back to the laboratory. There, after several days of careful chemical analysis, he found that the wallpaper contained high amounts of arsenic. Here was a possible source of the poison. But how did the arsenic get from the wallpaper into the people?

The Deadly Dye

Mr. Ellis remembered something from the chemistry books in his library. The books described hundreds of cases of arsenic poisoning from medical and police files. The cases were reported in Germany, France, Holland, Sweden, and the United States—just about all of the countries where there is a period of wet weather and where wallpaper was used in homes. These cases all seemed very similar to the one in the Forest of Dean.

So far as Mr. Ellis could tell, the story started in Sweden about 1800. Professor Karl Wilhelm Scheele had invented a green dye that contained arsenic. (In those days, arsenic compounds were often used in dyes.) Since its green was a very popular color, the dye was widely used in wallpaper. By 1815, in places where Scheele's

(Continued on the next page)

Dr. Weisberger is Professor of History at the University of Rochester; Dr. Klein is Caspary Curator of Plant Physiology at The New York Botanical Garden.

green dye had been used for 15 years, local doctors discovered that some of their patients were showing signs of arsenic poisoning; some had died. The police investigated and decided that the paper must have dried out and become brittle. They thought that tiny bits of the dye were flaking off into the air and were taken into people's bodies as they breathed.

About 1840, the professor of medicine and chemistry at Heidelberg University in Germany, Dr. Leopold Gmelin, was asked to look into several cases of arsenic poisoning. He came a "nose" closer to the truth. He smelled a faint odor of garlic in all the homes where people had died. Even more important, the garlic odor was not in the kitchen where you would expect it to be, but in the bedrooms. It was especially strong in damp places.

Now, Dr. Gmelin remembered that some arsenic compounds have a garlic-like odor. He decided that it was possible that the arsenic was in the form of a gas. The police then changed their minds about the arsenic coming from flaking bits of paper. But such cases were still marked: *"Death caused by arsenic from an unknown source."*

Mashed Potatoes and a Dead Mouse

How could arsenic in a wallpaper dye be changed into a gas? The answer to this big question came partly from Germany and partly from Italy. In the 1870s, Professor Wilhelm Fleck, working for the Public Health Service in Dresden, Germany, was assigned to investigate the arsenic poisoning problem. Dr. Fleck took strips of fresh green wallpaper and pasted them inside glass bottles. He then pumped in *moist* air from his laboratory. (Remember, Gmelin had found the garlic smell strongest in *damp* rooms.)

In about a week, Fleck saw that molds were growing on the paper strips. When this occurred, the bottles had a garlic-like odor. Chemical tests showed that the air in the bottles contained arsenic. Wherever there was the garlic odor, there was also a growth of mold. Could it be that the molds were changing the arsenic in the dye into a deadly gas? Was this the secret behind the unsolved poisonings?

In Italy, Dr. Bartolome Gosio went one important step further. He mixed some mashed potatoes with arsenic, put the mixture in bottles, and heated them to kill any mold or bacteria that might be in the mixture. Then he exposed the bottles to the air in homes where people had died of arsenic poisoning.

Dr. Gosio watched black, gray, red, and green spots of mold quickly appear on the potato. Like Dr. Gmelin, he sniffed and smelled a garlic-like odor. He then dropped a mouse into the bottle. Within seconds, the mouse stiffened; within a minute, it was dead!

Dr. Gosio had almost solved the puzzle of the arsenic poisonings. Apparently, in homes where the walls were damp, molds grew on the glue that held the wallpaper to the walls. One or more of these molds could change arsenic compounds into a death-dealing gas.

On the Track of a Mold

Italian experts could not chemically identify Gosio's gas, but the botanists tried to identify the mold. Dr. Gosio carefully took tiny bits of each of the colored spots of mold from the bottles. Each spot was put into a different bottle of mashed potato and arsenic. After the mold had grown, he smelled each of the many bottles until he found the one that had the garlic smell. The mold in that flask had a deep green color. It was identified as one of the Penicillium group of molds.

Even while Dr. Gosio was studying the mold, new cases of arsenic poisoning were being found. In Jena, Germany, a husband and wife were arrested on charges that they had poisoned their 11 children over a period of seven years. When the police found the green wallpaper in their home, the couple was freed. Fatal and near-fatal cases were found in Italy, England, Sweden, and in the United States. Wallpaper alone was not at fault. In the United States, bank clerks became ill from wetting their fingers with their tongues before counting stacks of money. The money was colored with green dyes that contained arsenic.

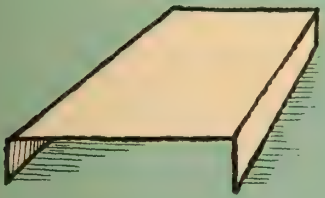
By about 1910, most countries had passed laws against coloring money, wallpaper, and wrapping paper with dyes that contained arsenic. Except where old wallpaper was still in place, few new cases of poisoning were found. Unfortunately, the home of the children in the Forest of Dean was one of these.

The final chapter in the story was not written until about 1940. The Royal Society of Great Britain and the Imperial Chemical Industries Company, which manufactured dyes, asked Professor Frederick Challenger, of the Chemistry Department of the University of Leeds, England, to see if he could discover the chemical nature of Gosio's gas. He was also to find out how the fungus made the gas.

Dr. Challenger worked for three years to finish the job. He found that the dampness changes certain arsenic compounds into a form which the Penicillium mold then changes into a poisonous gas called *trimethylarsine*. The innocent garlic smell of this gas disguised its danger.

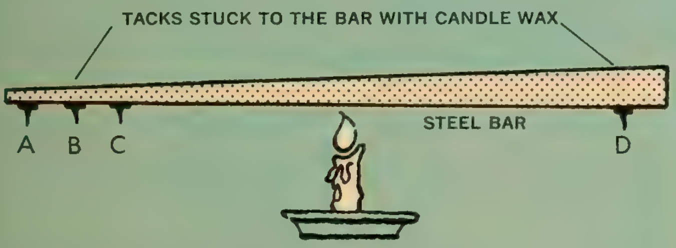
Today, the dyes used for paper are entirely different in chemical composition. Modern, weather-tight homes resist dampness. Through the century-long efforts of many scientists, the mystery has been solved and all danger removed. No longer will people be gassed to death by their walls! ■

brain boosters



CAN YOU DO IT?

Bend a stiff piece of paper as shown. Put it on the middle of a table, and try to blow it off in one breath.

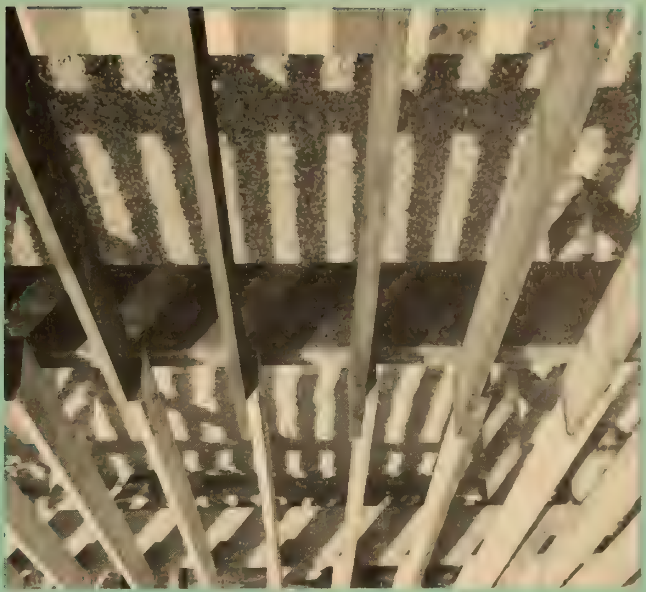


WHAT WILL HAPPEN IF . . . ?

In what order will the tacks drop off as the bar gets hot?

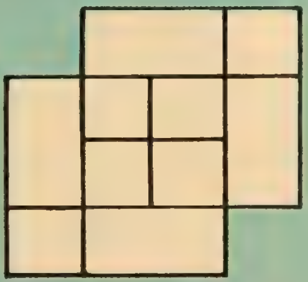
FOR SCIENCE EXPERTS ONLY

What is the biggest shadow you have ever seen?



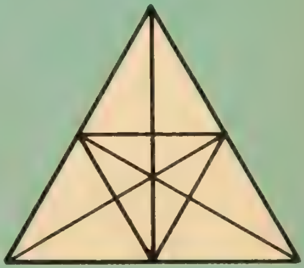
MYSTERY PHOTO What is it?

FUN WITH NUMBERS AND SHAPES



How many different squares are there?

submitted by Mary Carol Greutznacher, Port Lavaca, Texas

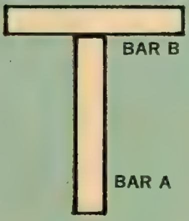


How many triangles can you find?

submitted by David Thomas, St. Petersburg, Florida

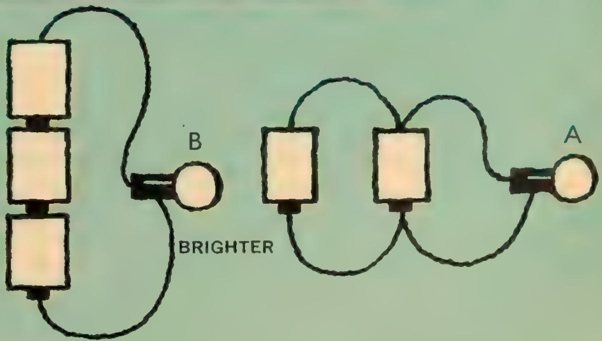
ANSWERS TO BRAIN-BOOSTERS APPEARING IN THE LAST ISSUE

Mystery Photo: The spiral shape is a curled wood shaving from excelsior packing.



Can you Do It? To find which bar is magnetic, you could touch one of the bars to the middle of the other one *(diagram)*. If Bar A is attracted to the middle of Bar B, Bar A is the magnet. If it is not, then Bar B is the magnet.

For Science Experts Only: What we caught we threw away; what we could not catch we kept. What is it? Answer: Bugs in our hair.

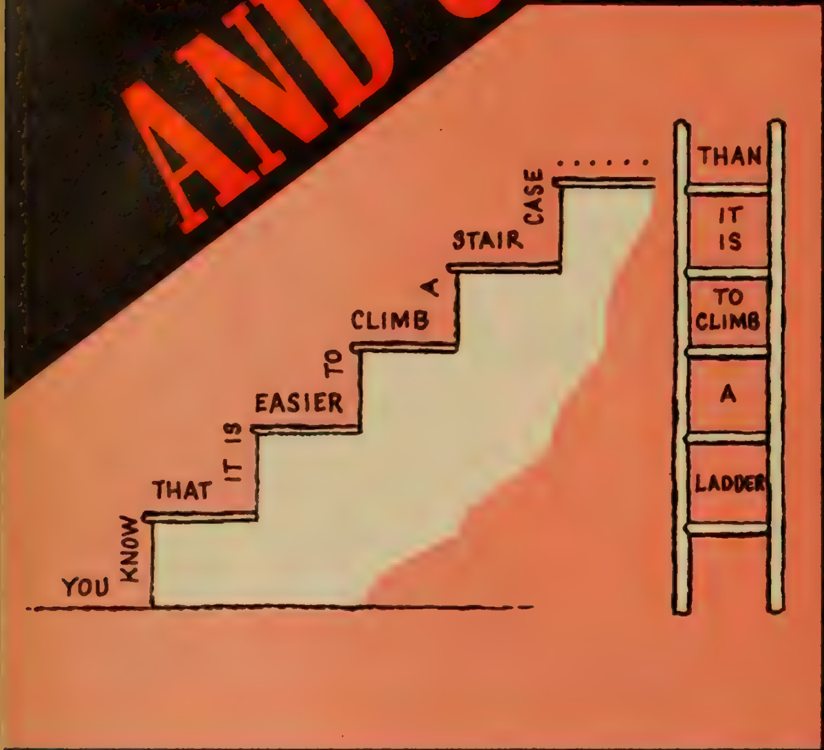


What Will Happen If . . . ? Bulbs B and C will light. Bulb B could be made brighter by turning one battery around as shown. Bulb A could be made to light by turning around the battery on the left side as shown.

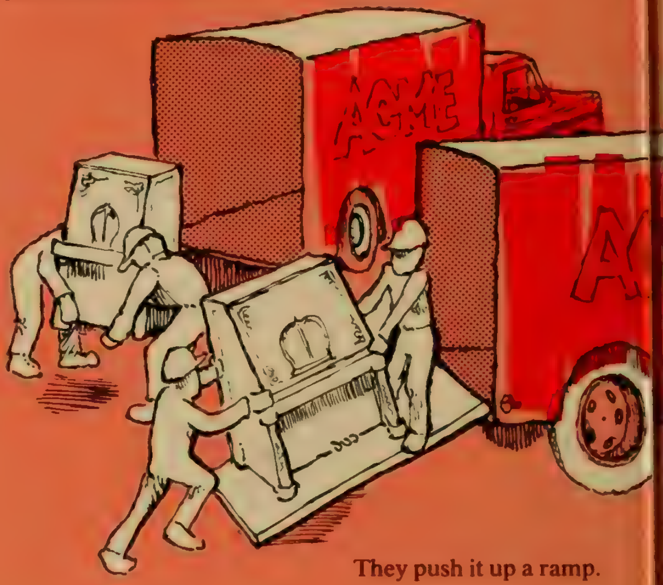
ONWARD AND UPWARD

The inclined plane has thousands of uses. Whether you are loading trucks or carrying something upstairs, it's much easier to lift things up at an angle than to lift them straight up.

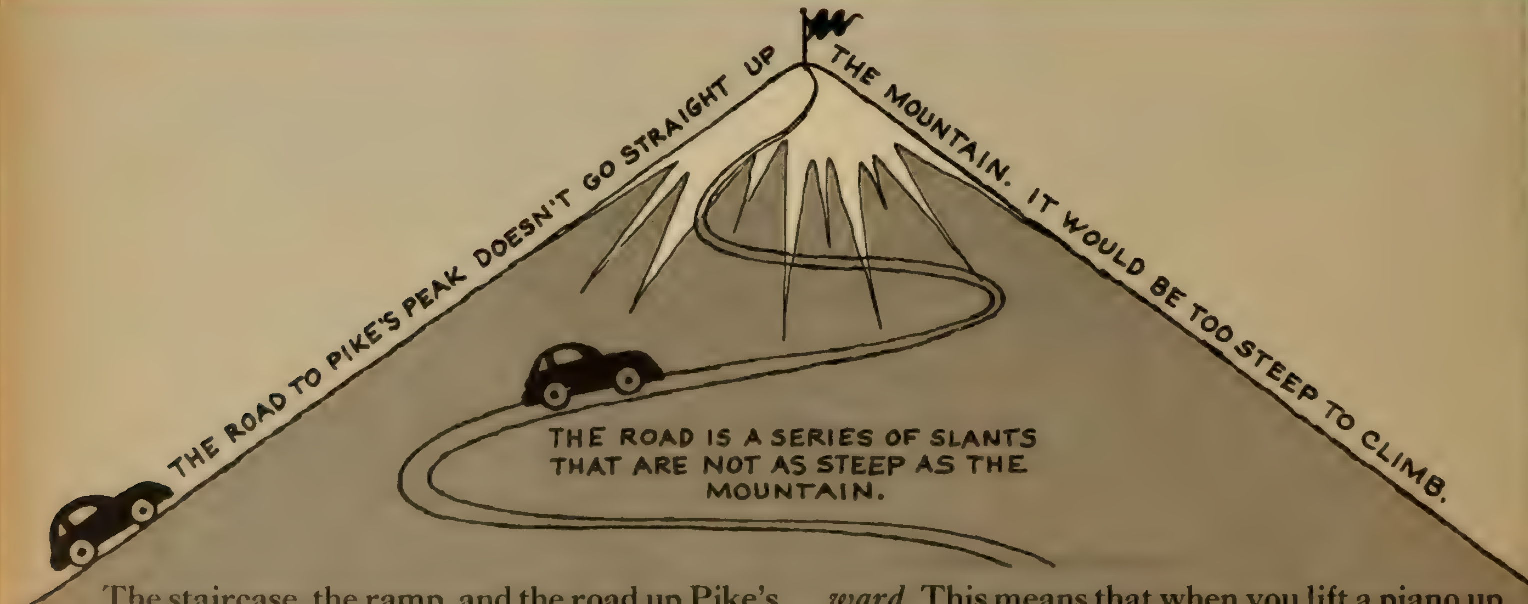
by James E. Frazer


YOU
KNOW
THAT
IT IS
EASIER
TO
CLIMB
A
STAIR
CASE
THAN
IT
IS
TO
CLIMB
A
LADDER

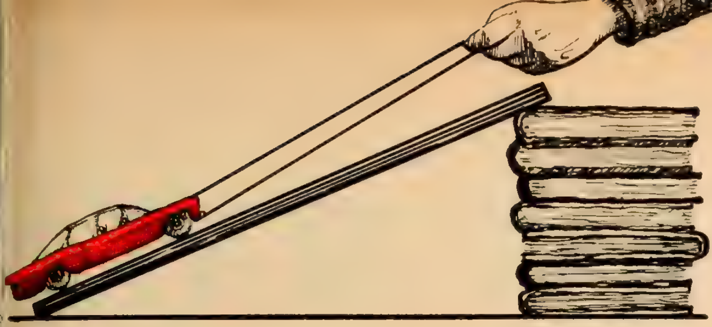
Movers don't lift a piano straight up from the ground to the truck.



They push it up a ramp.


THE ROAD TO PIKE'S PEAK DOESN'T GO STRAIGHT UP THE MOUNTAIN. IT WOULD BE TOO STEEP TO CLIMB.
THE ROAD IS A SERIES OF SLANTS THAT ARE NOT AS STEEP AS THE MOUNTAIN.

The staircase, the ramp, and the road up Pike's Peak are all *inclined planes*, or surfaces that slant. To lift yourself—or a piano—*upward* on an inclined plane, you also have to move *forward*. This means that when you lift a piano up a ramp, you have to move it a longer distance than if you lifted it straight up to the same height. Why, then, use an inclined plane?



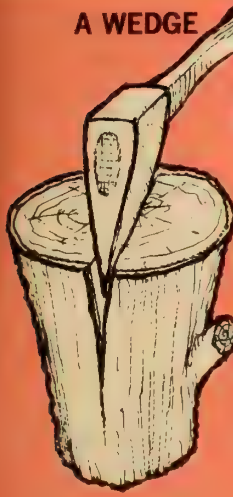
WHY USE AN INCLINED PLANE?

Get a rubber band that has a lot of spring in it. Hang different objects, such as a toy truck or a roller skate, from the rubber band until you find something that stretches it quite a lot.

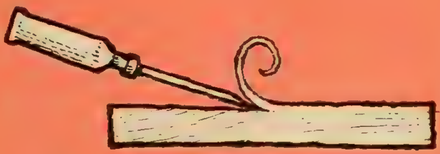
Now stack six or eight books on the floor and use a board about three feet long to make a ramp from the floor to the top of the stack. Place the truck at the bottom of the stack and lift it by the rubber band. While you are lifting it, measure the length of the stretched rubber band from your fingers to the truck. (The rubber band acts like the spring in a spring scale, so you can get an idea of how hard you are pulling to lift the truck from the length of the stretched band.)

Next, pull the truck up the ramp by the rubber band (*see diagram above*). Measure the stretched band as you pull the truck up the ramp. Did you have to pull harder to lift the truck straight up, or up the ramp? If the ramp were longer, would you have to pull harder, or less hard, to lift the truck on it?

A WEDGE IS AN INCLINED PLANE



An ax is a wedge. When you "push" this wedge into a piece of wood it "lifts" one part of the wood away from the other part.



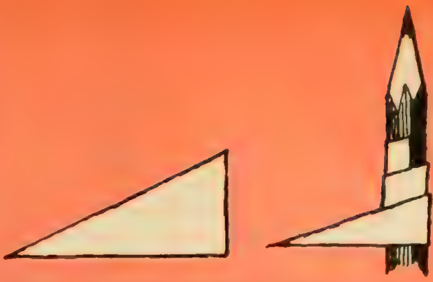
A chisel works the same way.

And what about a needle?

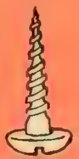
. . . or an arrow head?

. . . or a nail?

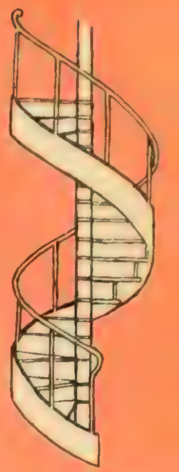
. . . or a fishhook?



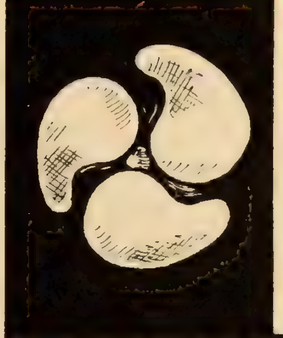
Wrap a paper inclined plane around a pencil and you have



. . . a screw



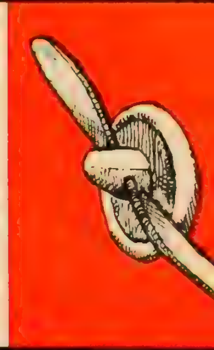
. . . or a circular staircase.



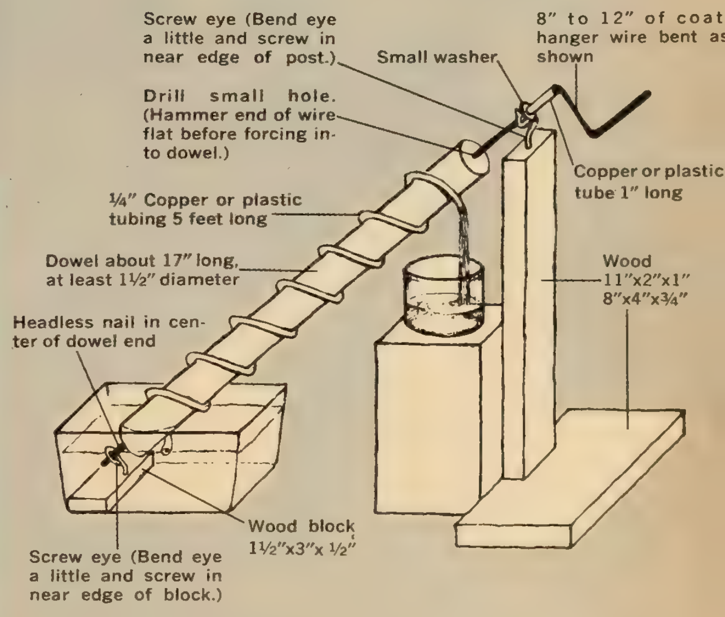
A boat propeller is called a *screw*. It "lifts" the water from in front of it to a position behind it, thus moving the boat.

. . . What about an airplane propeller?

. . . Or a helicopter blade?



LIFTING WATER WITH AN INCLINED PLANE—AN ARCHIMEDES WATER SCREW


Screw eye (Bend eye a little and screw in near edge of post.)
Small washer
8" to 12" of coat hanger wire bent as shown
Drill small hole. (Hammer end of wire flat before forcing into dowel.)
Copper or plastic tube 1" long
¼" Copper or plastic tubing 5 feet long
Dowel about 17" long, at least 1½" diameter
Wood 11"x2"x1" 8"x4"x¾"
Headless nail in center of dowel end
Wood block 1½"x3"x ½"
Screw eye (Bend eye a little and screw in near edge of block.)

As you turn the crank of the Archimedes screw, it scoops up water at the bottom and carries it to the top. Archimedes invented this "water pump" more than 2,000 years ago. You can make one any size, but this model works very well. The directions show one way of making a model. Warning: Don't use a dowel smaller than 1½ inches in diameter. If you do, the copper tube (or plastic tube) will tend to flatten as you wind it around the dowel. (You may have to fasten plastic tube to the dowel with sticky tape.)

TREES THAT MAK

by David Linton

■ Every minute of every day, the rivers of the world cut away land and carry it into the sea. In other places the waves are eating away the seashore. But there is one part of the world where new land is being made from the sea. In the tropics, new islands are being formed and coastlines are spreading out. This is happening chiefly because of a most unusual tree—the red mangrove.

Red mangroves live in the warm waters of the tropics. Unlike other trees, they can live in salt water. We do not know exactly how they are able to do this, but scientists are studying the mangroves to find out. The answer may help us develop simpler ways of getting fresh water from the salty sea water.

Most plants take in some air through their roots.
red mangrove has a tangled network of roots that
above the water's surface and take in air through
openings. Some roots send out branches, and s
branches send down roots, so the mangroves form a d
jungle.

Mangroves provide homes for a special community
animals. The upper branches are a nesting place for fri
birds, mangrove cuckoos, herons, and ibis. Lizards
themselves on the leaves. Purple-jawed hermit crabs ma
along the arching roots. A special breed of oyster, eag

1. Red mangroves bear flowers all through the year. From each flower develops a cone-shaped brown fruit. Its single seed begins to grow while the fruit is still hanging on the plant.

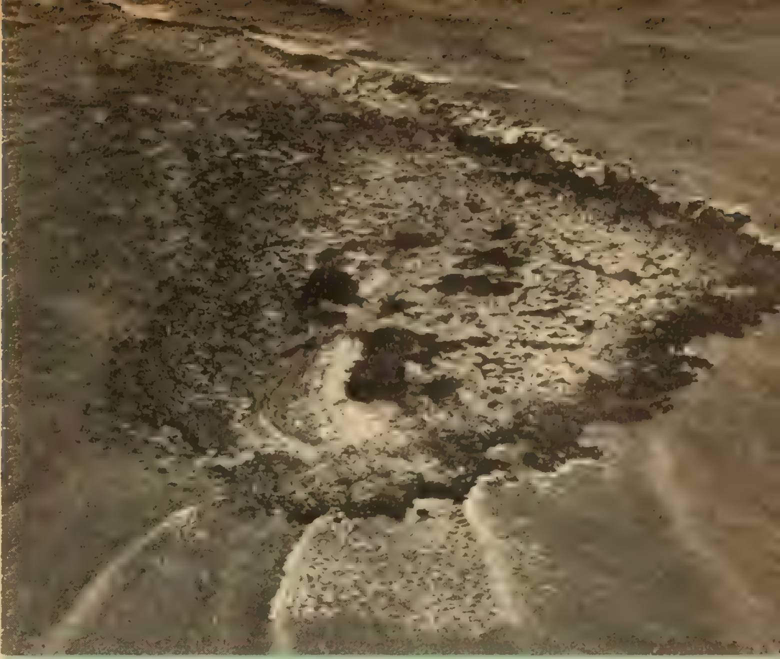
2. The young mangrove falls from its parent plant when it is about a foot long. It may take root where it falls, or may float in the water for thousands of miles. Eventually, the root end of the plant gets heavy and the plant floats in an upright position.

3. If the heavy end of the you
plant touches bottom — on
beach or sandbar, for instance—
puts down roots and starts to gro

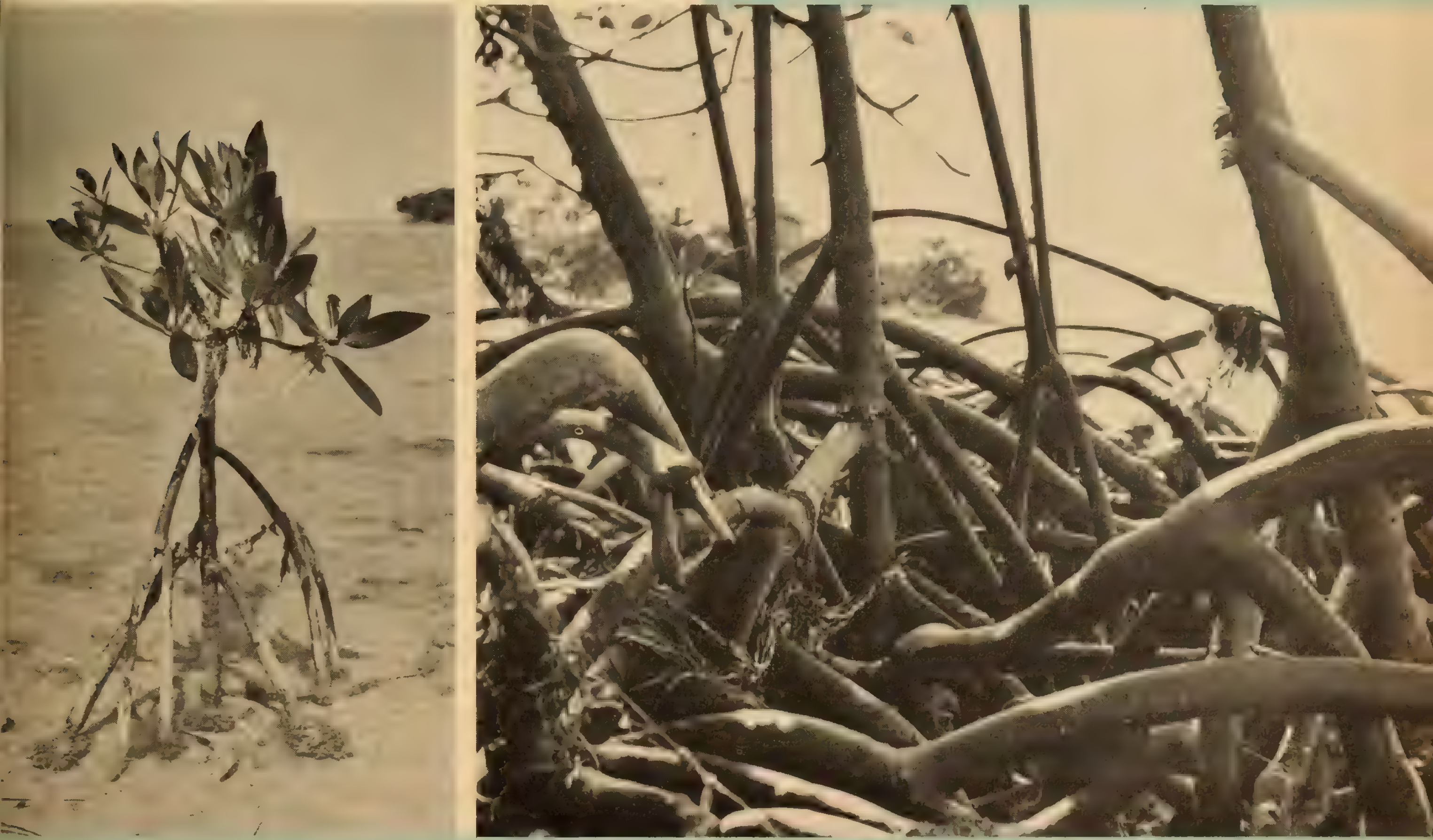
LAND

unted by raccoons, lives attached to the lower trunks. Alligators and crocodiles lie hidden under the low branches and roots, with only their eyes above water.

Men find it almost impossible to move in a mangrove jungle. There is no place to land a boat on many mangrove islands, and to go inland one must chop a trail through the mass of roots and branches. Such islands were a favorite hideout for pirates, and they are still a popular place to look for buried pirate treasure. But in the long run the red mangrove itself is more valuable than any treasure because it can make land from the sea. The pictures on these pages show how it is done ■



5. An island is born. Enough sand and other debris have been trapped among the mangroves to raise the land above the water level. New kinds of plants can get a root-hold on the island. Meanwhile, along the water's edge, mangroves will keep growing and spreading, forming more new land.

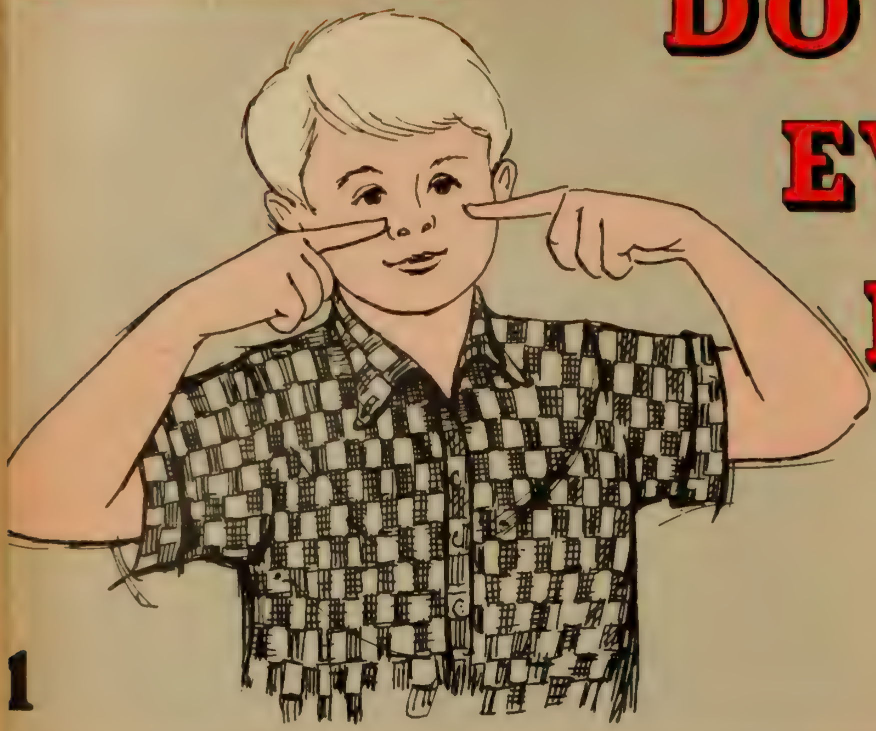


4. Mangroves grow rapidly, sending out prop roots for support (left). In time the network of roots and branches becomes so thick (right), that it traps whatever the sea washes into it. Sand, shells, driftwood, and seaweed pile up and give shelter to the plants and animals of the shallows. After a few years a sort of soil forms among the roots.

DO YOU EVER SEE DOUBLE?

by James R. Gregg

You can see a lot more with two eyes working together than with one eye working alone—even some things that aren't there.



1

■ When you look at a dog with your two eyes, two images are produced, one in each eye. Why is it you do not see two dogs?

You may say, "The two images are combined into one image in my brain." But this isn't always so. Only a few of the objects in your whole field of view actually appear as single objects. You can test this by using two fingers and your eyes.

First hold your forefingers pointed toward each other about six inches apart at eye level *(see Diagram 1)*. Now look between your fingertips at a distant object. Slowly move the tips toward each other. When they are about an inch apart, you will suddenly see a tiny "finger" floating in space between them. *You must keep looking at the far object in order to see the floating finger.* If you close one eye, the extra finger will disappear.

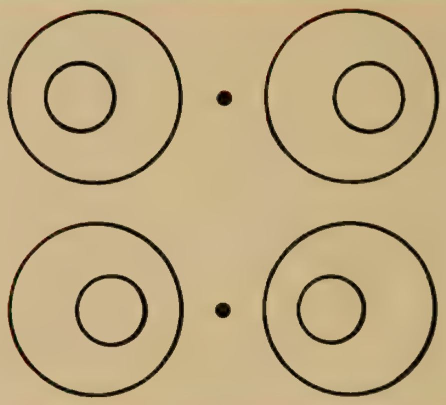
The "finger" you saw floating between the end of your forefingers was an *optical illusion*—a misleading view produced by your eyes and brain. You saw this illusion because your eyes see each finger double. In fact, if you hold one finger up while you look at a distant object and watch very carefully, it will look as if you have two fingers. If you aim both eyes at your finger, the distant object will appear double.

Only the objects that are very close to the point at which you aim your eyes appear single. Every other object appears double. However, you do not usually notice this, because you are paying attention to the object your eyes are aimed at, but not to the objects that appear double.

How Your Eyes See Depth

Now look at the top set of black rings in Diagram 2. Do all the rings look like they are flat on the paper? Take a pencil and lay it on the page with its point exactly on

2



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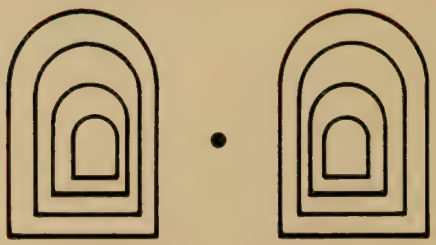
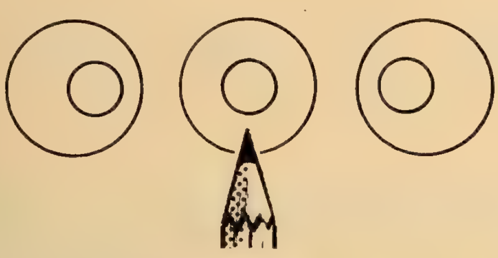


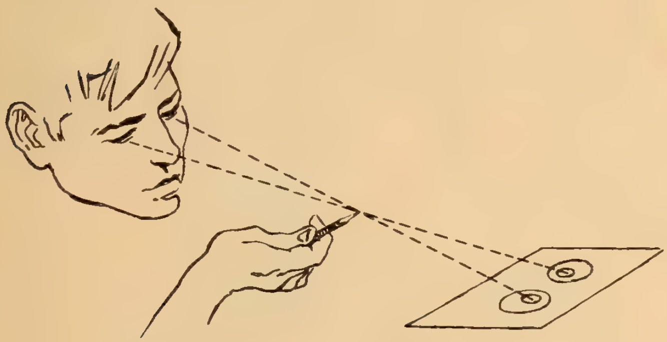
the dot between the sets of rings A and B. Keeping your eyes aimed at the pencil point, move the pencil very slowly toward your eyes. Keep moving the pencil closer until you see three sets of rings. Stop and hold the pencil where it is, about 10 or 12 inches from the page. Hold steady and you should see three sets like this:



Pay attention to the sets of rings over the tip of the pencil while keeping your eyes aimed at the pencil point. You may notice that the small inner ring has "floated" off the paper closer to you than the large ring. You may need to try several times before you see it.

Try the same thing on the second set of rings. This time the large outer ring will look closer. Next look at the arches in Diagram 3 in the same way. They will appear as though you are looking into a tunnel. This is a type of vision training exercise that is sometimes used to teach the eyes to work together.

Can you figure out why you see the rings and arches in this way? Look at the different pairs. You will notice that A and B are a little different. By looking at the pencil held close to you, your right eye aims at A and your left at the B set of rings, like this:



Each of your eyes sees a slightly different image. When they are blended in the brain, you see them in depth. That is why parts of the rings seem to be closer than other parts and why the arches look like tunnels.

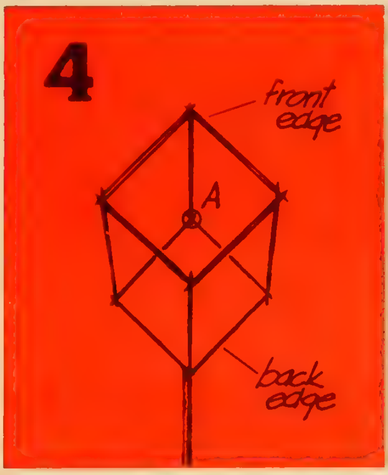
Draw some patterns of your own on paper. Try squares, triangles, and other shapes. Keep them about the same distance apart as the circles and arches. Try different colors. Then use a pencil and try to see the different shapes in depth.

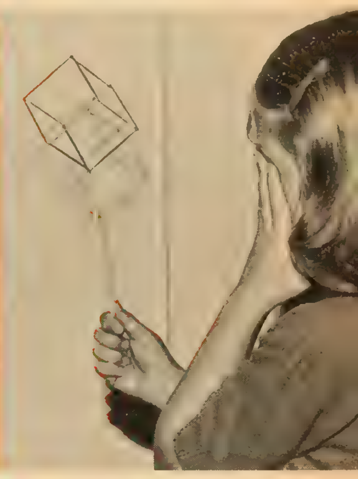
Fooling One Eye

This two-eyed depth effect is a very powerful one. It helps you judge distance from one object to another. In judging distance, you can fool one eye alone but not the two together.

Make a hollow cube by gluing 12 toothpicks together as shown in Diagram 4. Round toothpicks work nicely and they can be different colors, all one color, or uncolored. It is best to make two squares first, let them dry, then fasten the squares together with the remaining four toothpicks. Fasten a handle at one corner of the cube by gluing on a stick.

Now hold the cube in front of you exactly as shown in the photo. It is best to view it against a blank wall. The corner A must be pointing away from you and it must appear centered in the front side of the cube *(see Diagram 4). Close one eye* and look steadily at the corner A. Suddenly you will see the cube appear to reverse—corner A will look like it is sticking out towards you. Now slowly twist the handle and you will see the cube appear to turn in the opposite direction. Wiggle the handle. What do you see?





It may take several trials for you to see these things properly. Be sure the cube is positioned as shown. If it doesn't work, try a different background. It may help to move, tilt, and twist the cube a little. Remember, *it only works with one eye.*

This is known as the Von Hornbostel cube illusion. Your two eyes working together can see depth so well they are not fooled. But one eye gets mixed up about which part of the cube is closer ■

JUST CALL ME "B, MS/NS, P_1, CDe/CDe, Lu(a+), K-, Le(a-b+), Fy(a+)"

by Dorothy J. Buchanan-Davidson

How your blood type can be used to identify you.

This man is giving blood to a blood bank, where it is stored until someone needs blood of that type.

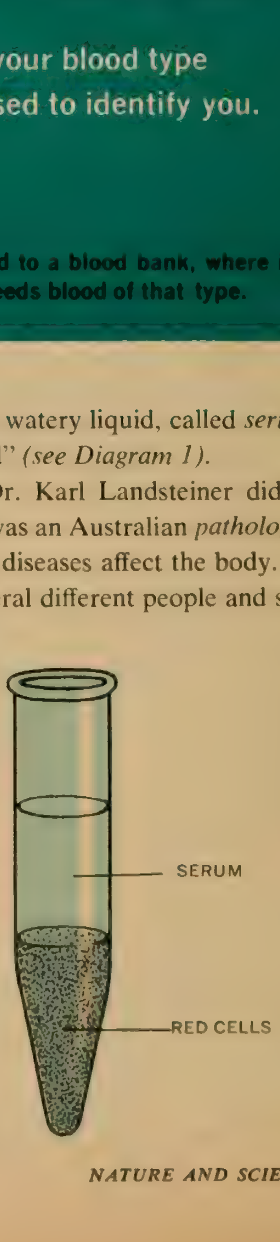
■ How many ways can you think of for proving who you are? Fingerprints surely are one of the best ways; but did you know that your blood can tell many things about you? Sometimes people can be identified by their blood alone.

If you went to a laboratory to be blood typed, they would give you a long series of letters that would be a really foolproof "name tag." Here is part of the blood type name tag of a boy I know: B, MS/NS, P_1, CDe/CDe, (Lu(a+), K–, Le(a–b+), Fy(a+).

To find out what blood type you are, first they would take a sample of your blood and put it in a test tube. Then they would whirl the test tube around in a machine called a *centrifuge.* A centrifuge works in a very simple way. Try to picture a jar of water with mud shaken up in it. The water would be all cloudy. Now if you could swing the jar around and around on the end of a long string, all the mud particles would go to the bottom of the jar and the water would be left clear.

Much the same thing happens to your blood when it is whirled in the centrifuge. Tiny particles of it, called *red cells,* go to the bottom. A watery liquid, called *serum,* is left above the red-cell "mud" *(see Diagram 1).*

Around the year 1900, Dr. Karl Landsteiner did an experiment. Dr. Landsteiner was an Australian *pathologist* —a scientist who studies how diseases affect the body. He took blood samples from several different people and sep-

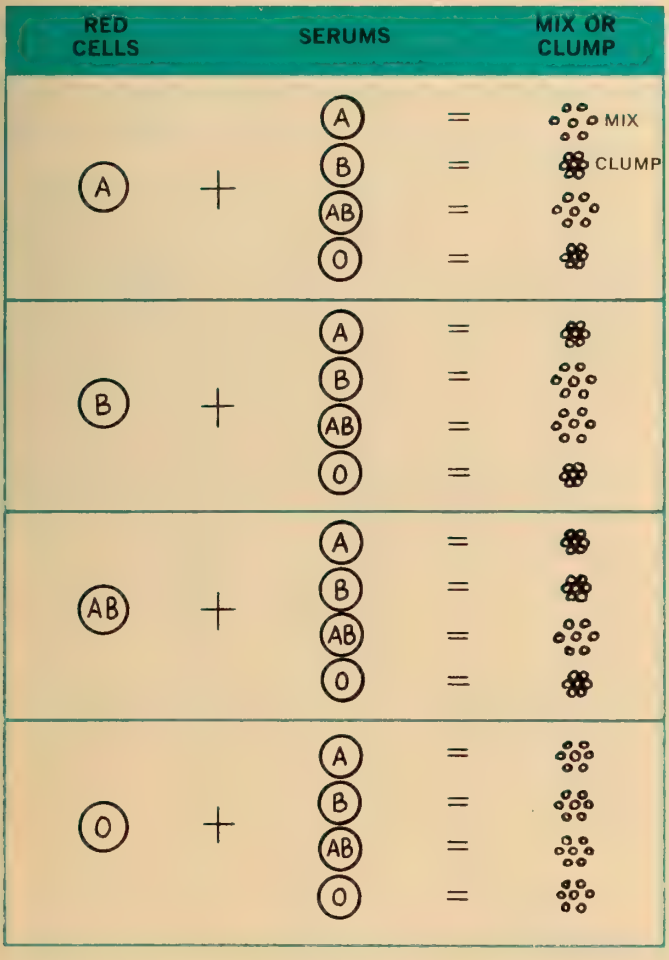


1 When a tube with blood in it is swung rapidly in a circle, the red cells, which are heaviest, go to the bottom and the clear liquid serum floats on top.

arated each sample into red cells and serum. Then he mixed one person's red cells with another person's serum. He was very surprised when he saw what happened. Sometimes, but not every time, the red cells came together in clumps. They would not mix evenly with the serum. Yet other times the red cells from one person did mix evenly with the serum from someone else's blood.

Clumps and Mixes

Dr. Landsteiner did many such mixing tests. He found out that there are four different types of blood, which he called type A, type B, type AB, and type O. If you have type A blood, your red cells will usually mix evenly with serum from type A or type AB blood, but your red cells will clump together in serum from type B or type O blood *(see Diagram 2)*. Red cells from type B blood mix with type B or type AB serum, but not with type A or type O serum. Type AB red cells mix only with type AB serum. But type O red cells mix evenly with all four types of serum.



2 If you have type A or type B blood, your red cells will usually mix with serum from blood of the same type as yours or with type AB serum. If you have type AB blood, your red cells mix only with serum of the same type. Serum of the "wrong' kind makes your red cells clump together. But type O red cells mix with any type of serum.

Why are the red blood cells of types A, B, and AB so "particular" about the serums they mix with? As it turns out, all serums contain many different kinds of substances called *antibodies*. These antibodies are very much like the ones that form in your serum to destroy a germ or virus when it gets into your blood. The blood group antibodies are what make red cells of type A, B, or AB clump instead of mixing when they are in the "wrong" type of serum. These antibodies do not affect type O red cells.

Red Cells Are Different in Other Ways, Too

What Dr. Landsteiner discovered was really just a start. The more that scientists manage to learn about our red blood cells, the more differences they keep finding. These "differences," by the way, are called *factors*. Some of them are known by letters like C, D, E, M, N, P, and S. Others are named after the persons in whom they were first found, such as Lutheran (Lu), Kell (K), Lewis (Le), and Duffy (Fy). The boy whose blood group name tag is printed in the title of this article has type B blood. The other letters stand for the different factors found on his red cells.

Right now we don't really know how many different blood group factors there are on red blood cells. New ones keep turning up. The present count is more than 100! Certain factors are found in almost every person. Others are found in only one family.

If you should ever need a blood transfusion, the doctors will test a sample of your blood with the blood that they plan to give you. They will not give you blood that will not mix with your blood. Also they will try not to give you blood factors that might cause your blood to form antibodies. Before doctors understood about blood types, many people died or became very sick after they were given a blood transfusion. Today transfusions can be given safely because your blood can be typed very accurately.

Not long ago there was a newspaper story about a woman who had a very rare blood group factor. Doctors knew that she was going to need an operation, and that during the operation she would need a blood transfusion. They could not find any blood that they could give her safely. What they did was to have her give some of her own blood. They stored the blood they took from her, then gave it back to her during the operation.

You have probably heard of blood banks. Healthy people can give, or sell, some of their blood to a blood bank. Giving some of your blood doesn't harm you, because

(Continued on the next page)

Just Call Me ... (continued)

your body quickly makes new blood that replaces the amount you lost. When doctors need a rare type of blood today, they simply phone certain blood banks. One such rare-blood bank is in a Massachusetts hospital. In addition, the American Red Cross and the American Association of Blood Banks (AABB) keep records of the names and addresses of people with rare types of blood.

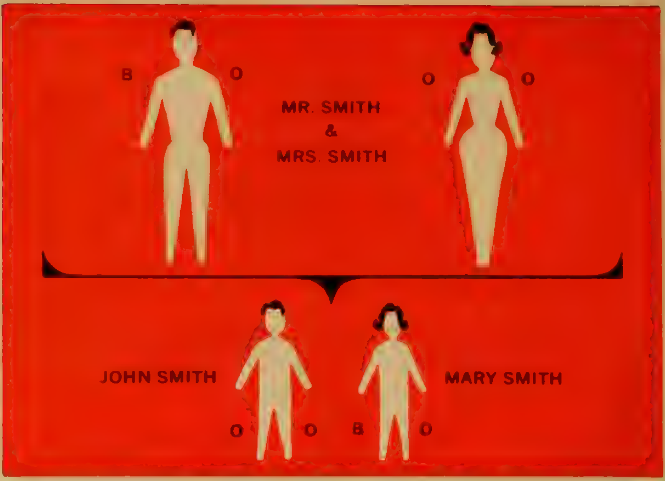
For example, not long ago, a woman in California needed a blood transfusion. No one with the same type of blood could be found in the continental United States. The Milwaukee, Wisconsin, branch of the American Association of Blood Banks looked in its files and found that three people in Hawaii had blood that could be used. Hawaiian doctors were notified, and an airplane was soon on its way to California with the rare type of blood.

What Makes Your Blood a Certain Type?

Your blood type came from your parents and your children will get their blood type from you and the person you marry. If your blood type is AB, one factor (either the A or B) came from your father and the other from your mother. Diagram 3 shows that Mr. Smith's blood factors are B and O, while those of Mrs. Smith are O and O. Each of the Smith's two children will have one blood factor from the father (B or O) and one factor from the mother (O or O). As you can easily see, there are only two possible blood types the children can have—BO and OO. The diagram also shows the blood types of three other couples. What blood types could their children have? Can you figure out why AO or BO type blood is usually listed simply as A or B type? *(See diagram 2.)*

Have you heard stories about the gypsies in Europe? No one could be sure where they came from. They had wandered far and wide, always moving from one place to another, for many generations. Scientists studied their blood types and showed that the gypsies most likely had come from India.

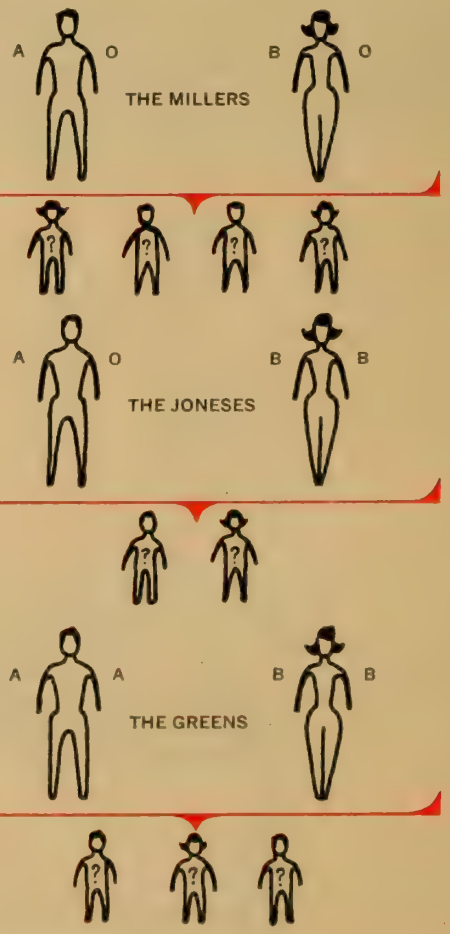
None of us can be singled out from all other people in the world by our major blood factor alone—that is, A, B, AB, or O. There are too many other people with the same major factor. But as scientists discover that our red blood cells have more and more factors, it becomes easier for them to single you out from many, many other people. Around 1900, Dr. Landsteiner predicted that some day people would be identified by their blood just as certainly as by their fingerprints. Now it is almost true ■



3 You received one blood factor from each of your parents. For example, John Smith (above) got O factors from each parent; Mary Smith got B factor from her father and O factor from her mother.

PROJECT

Here are three families, with the blood types of the fathers and mothers. Can you guess which blood factors each child might have?



Using This Issue . . .

(continued from page 2T)

straight up.

- *If it takes more work, what is the advantage of using the inclined plane?* The inclined plane increases lifting power. If it takes two pounds of pulling force to lift the weighted skate straight up, and only 1 pound of force to pull it up the ramp, the inclined plane enables you to lift twice as much weight with the same force. The number of times an inclined plane increases your lifting power is called *mechanical advantage.*

Theoretically, the mechanical advantage of an inclined plane can be found by dividing the length of the inclined plane by the difference in height between its top and bottom. Thus, a ramp 3 feet long that rises 1 foot gives a mechanical advantage of 3. But the *actual* advantage depends on the amount of friction between the ramp and the object moved.

- *How does an inclined plane increase your lifting power?* When you lift something straight up, you have to pull it upward with slightly more force than the downward pull caused by the earth's gravity. An inclined plane supports part of the object's weight, so you don't have to use as much force to lift it against gravity. The longer the ramp, the flatter it is; the flatter it is, the more of the object's weight it supports. That is why a longer ramp gives more mechanical advantage than a short one for lifting something a given distance.

- *How do a wedge and a screw differ from other inclined planes?* A wedge is simply an inclined plane that you push between two things to "lift" one away from the other. Its mechanical advantage equals the length of the slanted side divided by the length of the end opposite the "pointed" end.

Turning a screw, "lifts" material (wood, water, air, for example) along the spiral inclined plane. Mechanical advantage equals the distance along one spiral turn divided by the distance the screw "lifts' 'something during that turn.

- Have your pupils think of as many different examples as they can of the inclined plane, wedge, and screw.

PAGE 10 Trees Make Land

The red mangrove is an example (like the Kirtland's warbler) of this concept: *Organisms are adapted for survival in their environment.* Mangroves have evolved some of the most remarkable ways of reproducing to be found among land plants.

Although this article describes the red mangrove, other species of mangrove around the world have similar adaptations. The red mangrove can be seen along the coasts of southern Florida, the Keys, the West Indies, Mexico, and Central and South America. The black mangrove also grows along the Florida coast.

Topics for Class Discussion

- *Compare the seed production of mangroves with trees in more northern regions.* Notice that the mangrove bears flowers—and seeds—all through the year. Plants in temperate climates usually produce just one crop of seeds a year. Mangroves also begin to produce seeds when only a few years old; trees that grow farther north usually must be 20 years old or older before bearing seeds.

When discussing this topic, remind your pupils that they are dealing with *biotic potential*—an organism's natural ability to increase its numbers *(see "Animal Arithmetic,"* N&S, *Feb. 21, 1966).*

- *In what ways are the seeds of plants spread?* You will find the topic of *seed dispersal* presented in the WALL CHART of *N&S,* Nov. 2, 1964, and discussed on pages 2T and 3T of the same issue. The chart, "How Seeds Get Around," is also available as a 22x34-inch *Nature and Science* Wall Chart (No. 205), and in the *Nature and Science* Resource Study Unit, "Investigations with Plants" (No. 103).

PAGE 14 Just Call Me . . .

Here are the answers to questions posed on page 16 of this article:

- A person with AO or BO-type blood is usually listed as having A or B-type blood because A and B factors are usually the most important factors in receiving a blood transfusion. Red cells with the O factor mix with serum of all four types.
- In the project the Miller children might have AB, AO, BO, or OO blood factors. The Jones children might have AB or BO factors. The Green children could only have AB factors.

What Makes a Scientist Run?

(continued from page 1T)

Do or Dye

A colleague of mine who disdained lab coats once spilled some brilliant purple dye on his shirt—one of the fast dyes. Knowing that the spots could never be removed, he stripped off his shirt with hardly a second thought and dyed the whole thing a brilliant purple. He happened that day to be wearing a green and yellow plaid tie! From then on he acquired a habit of wearing a lab coat. For the majority of scientists the coat is merely a way to protect one's clothing.

The laboratory itself is a little community whose members are, or should be, devoted to the search for truth. The number of key members in this community varies. The English and Germans do this thing well. Any good English or German laboratory has a skilled shop man, a skilled stock attendant, and a bevy of skilled laboratory assistants or technicians. The average American laboratory is fortunate to have a stock man and/or shop man. Since in the States, for some paradoxical reason, there is never enough free money to hire qualified personnel for these glamorless but essential jobs, many labs are staffed by a motley array of singularly unskilled personages possessed with a curious affliction causing them to believe that the organization chart is an inverted pyramid. It is in the course of putting up with this sort of thing that the scientist reveals his real human qualities.

Passing the Word

The fact of the matter is that a scientist must be a jack-of-all-trades. Consider, for example, the publishing of research results. The end result of research is usually a published ac-

(Continued on page 4T)

What Makes a Scientist Run?

(continued from page 3T)

count of the data and conclusions. The motives for doing this are varied. For some people there is the fascination of seeing their names in print—a fascination that attains a high level of evolution in the arts. For others there is a desire, a desire that is the basis of all culture, to pass on acquired information.

In any case, people love to recount their experiences. Some people feel so compulsive about this that they invent experiences. This is sometimes known as fiction. Today in science, fiction is frowned upon at all times.

The desire to recount one's experiences may be quite innocuous or it may be for personal aggrandizement. On the other hand, in some scientific circles one's promotion and permanancy may depend upon the number, weight, or volume of his published works (seldom on the quality, in these institutions). A scientist I once knew was arraigned in court for threatening bodily harm to a colleague. The accused threatened to hit the defendant with his (the defendant's) published works.

For a good number of scientists, however, publication is the partial fulfillment of a desire to make available to the world a little fragment of knowledge painstakingly acquired. Since our knowledge of the world is built up of the infinite fragments of knowledge acquired by numberless individuals over all ages, the only way in which the fragments can even be pieced together into a whole, into truth, is by permitting the gleaners of the fragments some knowledge of contributions of others. For this the scientist exposes himself to the ordeal of publishing.

Getting the Muses Together

For ordeal it is indeed. Some people never face it so that the knowledge they gained is forever locked up in their own consciousness. To publish one must write. The muse of research is frequently a total stranger to the muse of speaking and of writing. Many a scientist is a stranger to his native tongue.

In a rough sort of way there are official means of compensating for this lack. After a research worker has written five or six drafts of his message (the final one frequently bears a remarkable resemblance to the original), he selects a scientific journal to which to send the manuscript. Ideally the journal should be selected on the basis of its subject matter and on its circulation. More often than not a given journal is selected because the lag between acceptance and publication is less than a year. Also, unfortunately, a publication is commonly selected because it has a reputation of never refusing a manuscript.

Having reached the editor's desk a manuscript then goes the round of referees. A scientist's work is judged by his peers. Reviewing manuscripts is one of the fringe duties of scientists, the majority of whom feel that with the privilege of being a scientist there are certain obligations, one of which is to give to other scientists the benefit of their knowledge in their areas of competence.

If a manuscript survives the scrutiny of referees, it receives a going-over from the editor. Editors come in all shapes, sizes, abilities, and philosophies. Some are frustrated writers with a firm conviction that they and only they are masters of the English (or German, French, etc.) language. A manuscript that has passed through their hands resembles a modernistic etching in blue. At the opposite extreme is the editor who believes that the illiteracy of the writer should be exposed for all to see. Between the two are innumerable sub-species.

A scientist is usually judged by his published works. In them he is exposing his very soul. In the long run, incompetence and fraud will out, because every statement is open to verification.

But the rewards are great. These rewards may be monetary—though this is exceedingly rare—they may be security, they may be honor. One of the more pleasant rewards is a passport to the world, a feeling of belonging to one race, a feeling that transcends political boundaries and ideologies, religions, and languages. The successful scientist has colleagues in all lands, and his work is a passport to the far corners of the world. And among his colleagues he develops lasting friendships. And with friendship comes, if not understanding, at least sympathy.

The Need To Know

But are these the real reasons for being a scientist? I think not. The real reason I believe is more lofty and more subtle. In this I do not mean the heroics of wanting to banish pain and misery or to advance technology. Arrowsmith was really a caricature of a scientist. It is not in this manner that a scientist has nobility. It is in a far more subtle mode, a mode that many scientists themselves may never recognize, for one of the characteristics that sets man apart from all the other animals (and animal he undubitably is) is a need for knowledge for its own sake.

Many animals are curious, but in them curiosity is a facet of adaption. Man has a hunger to know. And to many a man, being endowed with the capacity to know, he has a duty to know. All knowledge, however small, however irrelevant to progress and well-being, is a part of the whole.

The instrument of a scientist's destiny may be many things from the ultimate space of the farthest reaches of the universe to the ultimate particles of matter, and all things in between, not excepting man himself. It is of this the scientist partakes.

A fly is just as much in the scheme of things as man. No less a person than St. Augustine remarked in the Fourth Century: "For it is inquired, what causes those members so diminutive to grow, what leads so minute a body here and there according to its natural appetite, what moves its feet in numerical order when it is running, what regulates and gives vibrations to its wings when flying? This thing whatever it is in so small a creature towers up so predominantly to one well considering, that it excels any lightning flashing upon the eyes." To know the fly is to share a bit in the sublimity of Knowledge. That is the challenge and the joy of science ■

nature and science

TEACHER'S EDITION

VOL. 3 NO. 14 / APRIL 4, 1966 / SECTION 1 OF TWO SECTIONS

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A New Look at the Weather

by Gerald L. Shak

■ Even the most gifted scientist cannot work with unreliable data. The meteorologist's data are the myriad observations made by men and machines comprising a network of thousands of weather observatories scattered over and above the earth.

Observations are the building blocks of a weather forecast. The forecaster's ability to arrange them depends on several things: uniform standards for exposing observational equipment, uniform procedures for recording data, and getting the data from one place to another quickly.

Rapid transmission of accurate data and rapid processing of the data are essential. The new meteorology, therefore, is developing around automatic observatories (such as weather satellites and rockets) and computers that can rapidly process the continuous flood of data.

Gerald L. Shak is User Services Representative, U.S. Weather Bureau, Eastern Region, New York.

COMING SOON: SUMMER ISSUES

If you receive Nature and Science in class quantities, you will soon be mailed the announcement of this year's Summer Issues. The form accompanying the announcement tells how you can order the two Summer Issues for delivery to your pupils at their home addresses, and describes the valuable books you can receive FREE for your participation. Every child in your class will benefit from a subscription to the Nature and Science Summer Issues.

Surface Observation

Automatic instruments are now being used to measure temperature, precipitation, wind, radiation, visibility, and relative humidity, and to make chemical analyses of the air. Chemicals sensitive to changes in water vapor content of the air send coded electrical signals to recorders in weather offices.

An automatic instrument that measures cloud height is replacing the balloon technique of making such measurements. When light of a certain frequency is projected onto the cloud base, the light spot on the cloud is detected by a ground-based photo cell device that computes the ground-to-cloud distance trigonometrically, then transmits this information over telephone lines to receiving stations.

These and other instruments are now being combined into Automatic Observing Systems (AMOS) and set up in inaccessible areas on land or anchored at sea *(see photo on page 7)*. These automatic observatories collect, compute, and code their observations, then transmit them to hundreds of weather stations over teletypewriter lines.

Upper Atmosphere Measurements

For many years meteorologists have been exploring the upper atmosphere with small instrumented radios carried aloft several times a day by helium or hydrogen balloons from hundreds of stations around the world. Radio signals sent back by the balloons' transmitting devices carry information about temperature, air pressure, and relative humidity for all levels up to 100,000 feet. Wind speed and direction are found by tracking the balloon with radar. New devices will soon transmit these data directly to computers for rapid analysis and automatic transmission to forecast offices around the world.

(Continued on page 4T)

nature and science
What To Do When Lightning Strikes (see page 5)

IN THIS ISSUE

(For classroom use of articles preceded by ●, see pages 2T and 3T.)

● Inside a Thunderstorm
This article tells how thunderstorms begin, mature, and dissipate; what scientists know about lightning and thunder; what to do in a thunderstorm.

Weather Sayings—How True Are They?
The scientific basis for four familiar bits of weather lore.

A New Look at Weather
Some devices that have widened the meteorologist's horizons and speeded up the job of forecasting.

● Where Do the Winds Come From?
This WALL CHART shows your pupils how movements of the earth's atmosphere produce the prevailing winds and what causes the movements of air parcels that produce local winds.

Make Your Own Weather Station
With commonly available materials, your pupils can make four basic weather instruments and use them to investigate weather phenomena.

Checking Up on the Weather
Your pupils can discover weather patterns in their area by recording data obtained with their homemade instruments on graphs that correlate variations in wind direction, atmospheric pressure, relative humidity, and rainfall.

IN THE NEXT ISSUE

The "taming" of viruses: how vaccination was developed . . . Your pupils can make a matchbox computer that learns as it plays a simple game . . . What is it about an owl that triggers mobbing attacks on it by smaller birds?

USING THIS ISSUE OF NATURE AND SCIENCE IN YOUR CLASSROOM

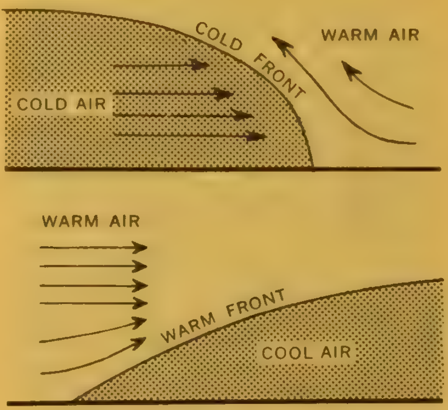
This special-topic issue introduces your pupils to the science of meteorology by exposing them to the mechanics of such basic weather phenomena as thunderstorms, lightning, and the winds. It tells your pupils how to make four simple instruments for measuring basic weather elements—wind direction, temperature, relative humidity, barometric pressure, and rainfall. Your pupils can learn to correlate data obtained with these instruments to find patterns in the weather in their area. Their understanding of weather phenomena can also be extended by making simple observations suggested in projects and investigations in the issue.

PAGE 2 Thunderstorms

Although July and August are the months when the greatest number of thunderstorms occur over most parts of the United States, you may get a few in your area before school closes. (December and January bring the fewest thunderstorms.)

One activity that lends itself particularly well to classroom use is an investigation into the most frequent cause of thunderstorms in a given area. As an article points out, thunderstorms are generated by moist air rising in the atmosphere. This can happen because 1) the air is warmed by local heating of the land, 2) moist air is driven upward as an air mass crosses a mountain range, or 3) moist air is pushed aloft by an incoming mass of cold air.

An explanation of weather fronts is beyond the scope of the student's edition article. Essentially, a cold front is the zone of contact where the leading edge of a mass of cold air wedges its way beneath a mass of warm air *(see diagram)*. Foul weather may be expected all along the frontal zone. A warm front results when a mass of warm air flows up over a mass of cold air.



You can demonstrate a frontal zone to your class by half filling a small jar with water tinted with red food coloring. Fill the jar the rest of the way with cooking oil. Because the oil is lighter than the water, it will ride on top. If you cap the jar, then tip it over on its side, there will be a turbulent boundary of oil and water until the liquids stabilize again. The turbulent boundary layer will serve as a crude analogue to a weather front.

With an understanding of the three processes leading to thunderstorm activity, your pupils should be able to make some well calculated guesses about which one caused yesterday's storm. You might want to start a bulletin board record of thunderstorms and encourage your pupils to keep it up to date, recording the date, time, and duration of each storm; whether it began and dissipated in your area or was just passing over; the direction in which it was moving; and finally, a remarks column. You could lead your pupils in a discussion of the cause of each storm they record—frontal activity, say—and enter their conclusions in the remarks column. Encourage them to look for *patterns;* possibly frontal activity is the major cause of thunderstorms in your area during a certain season.

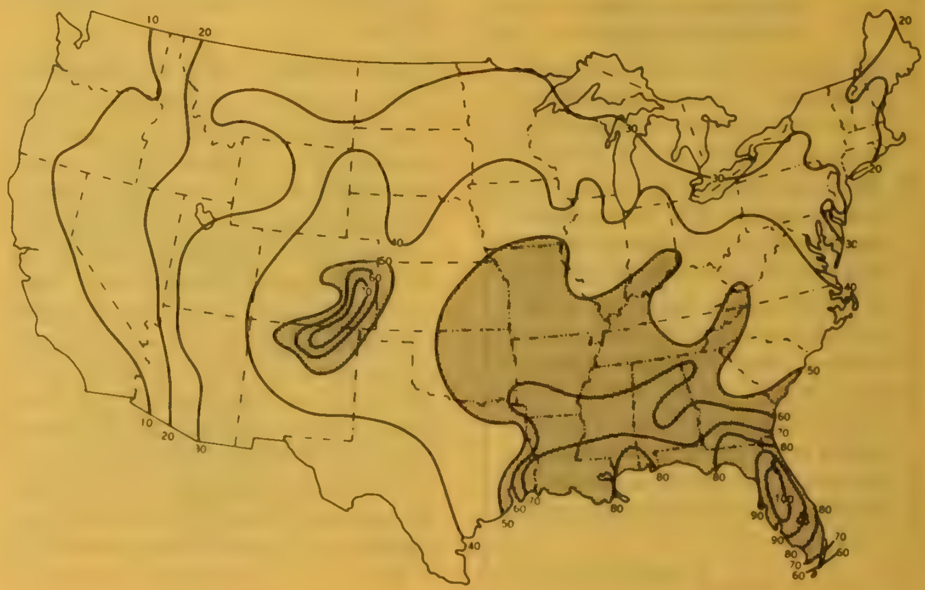
Those of you who live in the south central and southeastern parts of the country have enough storms *(see map)* to make this activity particularly worthwhile.

Topics for Class Discussion

Man's attempts to explain the reasons for thunderstorms have given rise to many superstitious ideas. Norsemen believed that thunder was caused

(Continued on page 3T)

AVERAGE NUMBER OF THUNDERSTORM DAYS PER YEAR



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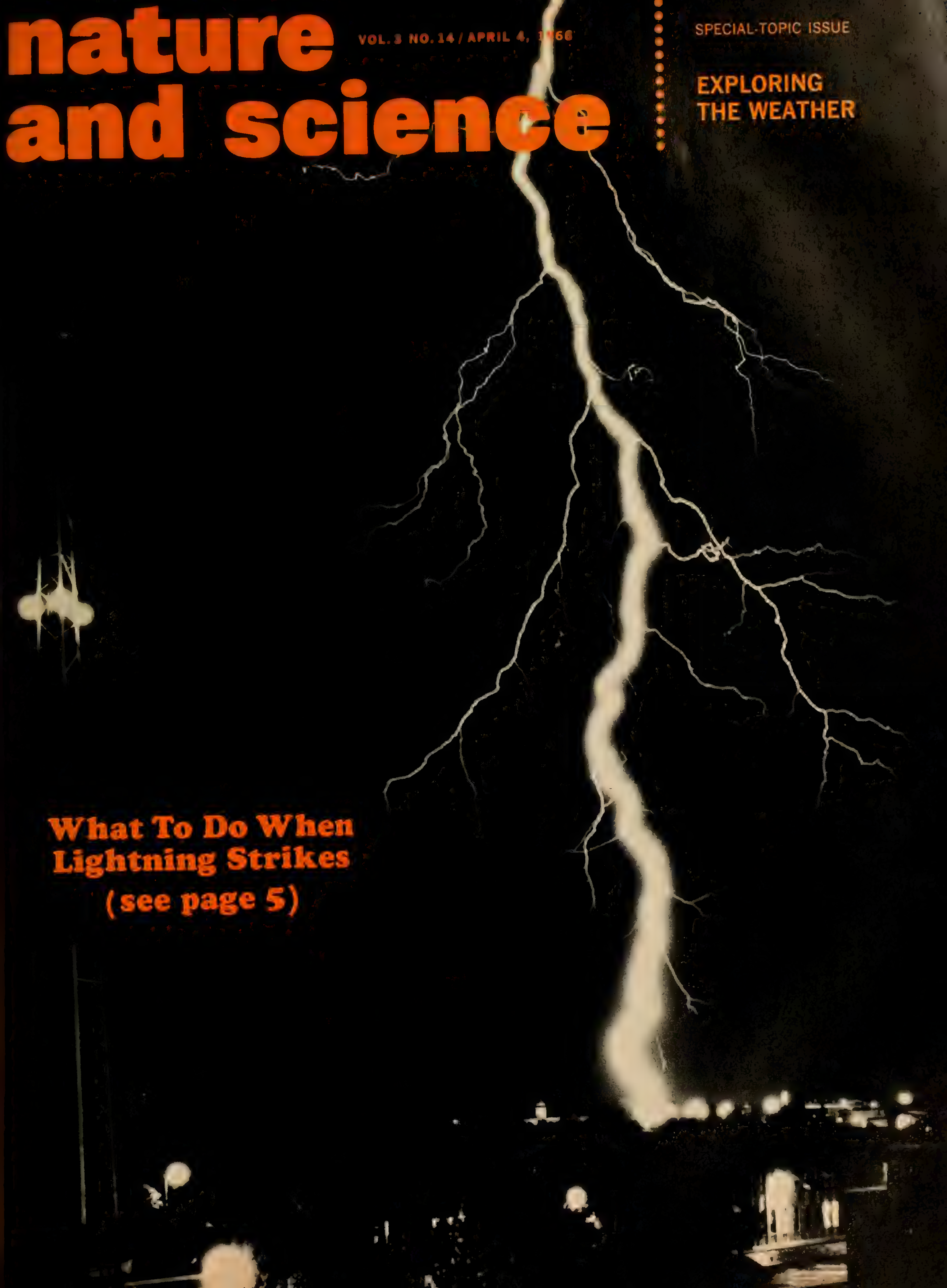
nature and science

SPECIAL-TOPIC ISSUE

EXPLORING THE WEATHER



What To Do When Lightning Strikes (see page 5)

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INSID
THUNDERSTOR

The thunderstorm "season" is coming. Be on the lookout for these fascinating storms—there is muc you can learn from them (CRACK) from the safety (BOOM!) of your living room (rummmble).

■ At this very moment there are about 2,000 to 3,00 thunderstorms raging over the earth. Some are destroyin property and life, others are causing floods; nearly all o them are giving many people good cause to worry.

Perhaps you have heard someone tell of a fearful 1 minutes or half hour spent in an airplane that was force to pick its way among a group of thunderstorms. It ca be a frightening experience, even for a veteran pilot. Stron currents of air, called *updrafts* and *downdrafts*, can toss large airplane about as if it were a toy glider. Heavy rains snow, hail, or all three, may batter the aircraft and form ice on its wings. Add thunder and lightning to all the rest and the experience can be one that stays with you for life

Thunderstorms in the Making

How many severe thunderstorms have you bee through? If you live in the southeast near the Gulf Coast you probably have been through many, because conditions there are just right for thunderstorm breeding. But if yo live in the far west or northeast, a fierce thunderstorm is a rare event. Sometimes a thunderstorm builds up graduall and you can watch it develop. Other times the storm seems to be upon you suddenly, without warning.

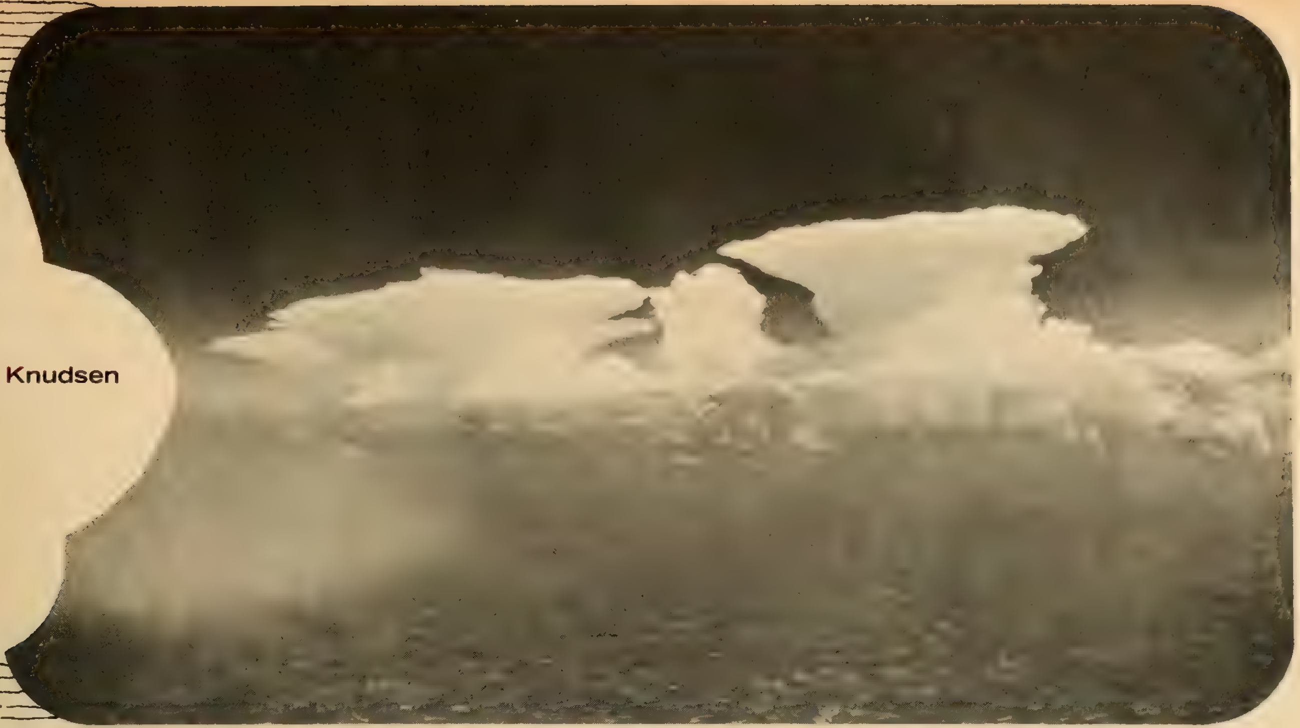
Just what are the "conditions" that make things right fo

INVESTIGATION

Begin now to keep track of thunderstorms. Each time you have one, make a note of the time of day or night. By the end of the summer you will know whether there are more thunderstorms during the day or night where you live.

A

by
Charles Knudsen



This spectacular aerial photograph of thunderheads shows a line of thunderstorms. The small one in the middle is a "young" storm in the cumulus stage. Those to the right and left are more advanced. *(See diagrams on page 4.)*

thunderstorm formation? One of them is moist, warm air. When the meteorologist uses the term "moist" air he means air that has a lot of *water vapor*—water changed to gas. (When water from a puddle or the ocean evaporates into the air, it changes into water vapor.) Before a thunderstorm can develop, moist, warm air must be carried high into the atmosphere. There are three ways this can happen:

1. A mass of cold air (always heavier than warm air) may come along and wedge its way under the moist, warm air, lifting the warm air high into the atmosphere.
2. A mass of moist, warm air traveling overland may come to a mountain range and be forced to rise over it, cooling as it rises (*see chinook wind, page 9*).
3. On a summer afternoon the land may become hot and force moist air passing over it to rise, just as heat from a radiator causes air above it to rise.

Whichever process causes moist air to rise, the same thing always happens: clouds form. When the moist air cools high in the atmosphere, its water vapor changes back into liquid water—collections of tiny droplets which we see as clouds. On a hot summer afternoon, which is a good time for a thunderstorm, the clouds may begin as *cumulus* clouds, which look like puffs of white cotton. The clouds may grow, some of them combining and forming a *cumulonimbus* cloud. These clouds are the giants among the cloud family and look like great cauliflower plants.

A cumulonimbus cloud that is about to unleash a thunderstorm is known as a *thunderhead*. Sometimes one of them alone forms and produces a single, or *one-cell*, thunderstorm. Such storms are rarely larger than 10 miles across, and they last from about 20 to 90 minutes. Sometimes a line of thunderheads hundreds of miles long may form and produce many dozens of storms in different stages of development. These lines of storms, which can be extremely violent, are called *squall lines*. They are quite common east of the Rocky Mountains to the East Coast, but the most active region is the Mississippi Valley and the Gulf States.

The *cumulus stage* of a thunderstorm is its "youthful" stage. A cumulus cloud developing into a thunderstorm has many updrafts, winds that blow upward into the cloud

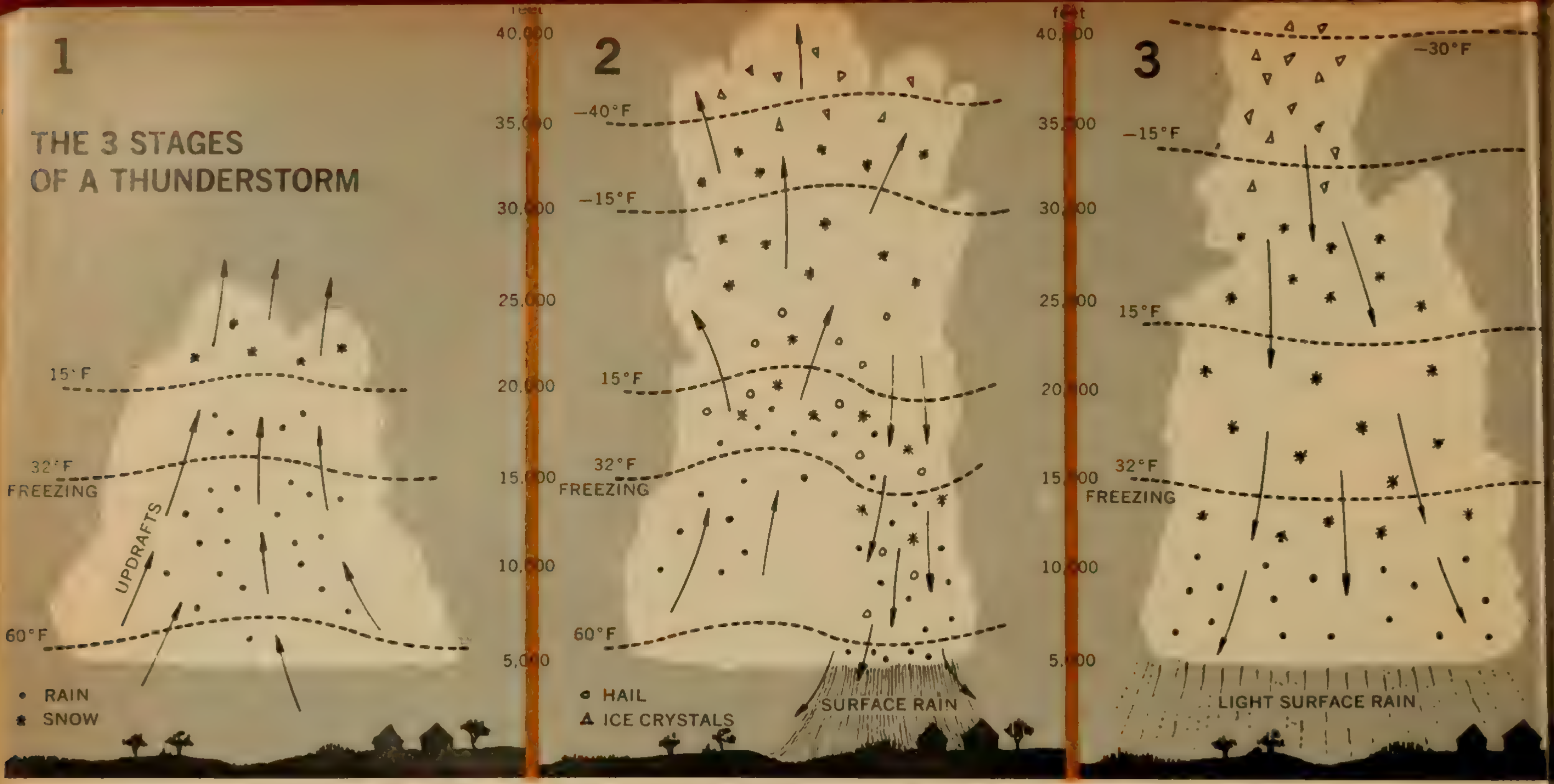
(Continued on the next page)

ABOUT THE COVER

Our cover photograph shows a whopper of a lightning bolt striking the University of Arizona campus. Although on his toes, the photographer was not as quick as the flash. He left his camera on time exposure and waited hopefully for lightning to strike. When it did, it acted as a giant flash bulb, lighting nearby buildings.

Around the world, lightning strikes 100 times a second, on the average. Lightning kills about 230 people each year in the United States—more than are killed by tornadoes or hurricanes—and starts about 27,500 fires. Many people are terrified whenever lightning strikes, but there is little reason to fear lightning or thunderstorms if you know what to do when a storm strikes (*see page 5 for safety rules*).

This special-topic issue about the weather was prepared under the editorial direction of Roy A. Gallant, with Charles G. Knudsen, Chief, Operations, U.S. Weather Bureau, Eastern Region Headquarters, John F. Kennedy International Airport, New York, N.Y., as consultant.



These diagrams show the three stages of a growing thunderstorm: 1. In the *cumulus stage* the cloud has updrafts only. Rain droplets are not heavy enough to fall out of the cloud. 2. In the *mature stage* there are downdrafts as well, which are felt as gusty surface winds. Rain, and sometimes hail, fall from the cloud at this stage. 3. In the *dissipating stage* the cloud top develops an anvil, updrafts cease, and surface rains become lighter.

Inside a Thunderstorm (continued)

and out through its top. The updrafts may reach 30 miles an hour or more (*see Diagram 1*). Although water droplets forming the cloud have grown into raindrops, the drops are not yet heavy enough to fall out of the cloud as rain. The updrafts hold them inside the cloud.

During the storm's *mature stage*, or "middle age," the rain droplets become heavy enough to fall out of the cloud as rain or ice. As Diagram 2 shows, during the mature stage the cloud tops rise much higher. Raindrops falling through the cloud drag air down with them. The air in these downdrafts moves up to 20 or 30 miles an hour near the center of the cloud. As the downdrafts sweep toward the ground they tend to spread out sideways, causing cool and gusty surface winds. Meanwhile, updrafts within the cloud may continue to build up, moving air at speeds of more than 60 miles an hour. These strong updrafts and downdrafts are the main reason why pilots try to avoid thunderheads.

In the thunderstorm's "old age," called the *dissipating stage*, there are only downdrafts. No more moisture "fuel" is being fed into the cloud from below, so the cloud's air becomes dry, the rain or hail becomes less, and the downdrafts slower. The lower parts of the cloud lose their cauliflower shape and become flatter while the top parts spread out, taking the shape of an anvil (*see photo on page 3*). Even though the cloud is in its decaying stage, it can still produce severe weather, but the anvil and flat bottom layer are signs that the cloud is dying.

PROJECT

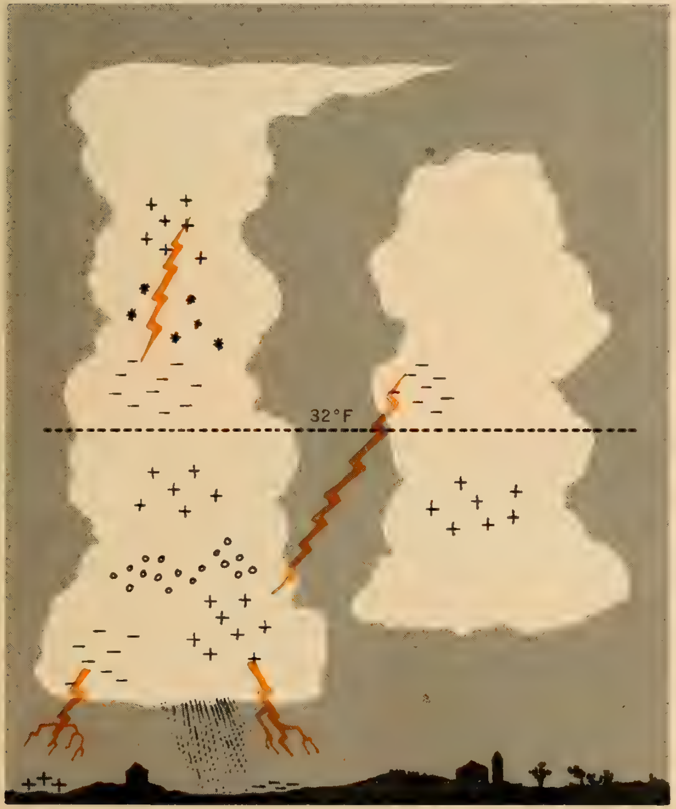
Be on the lookout for thunderstorms. When one comes your way, see if you can tell what stage it is in. A storm may begin nearby but move away from you before it has ended. Other storms may begin several miles away from you, then move overhead only when they are "middle age" or "old age."

Lightning and Thunder

To this day some people believe that lightning and thunder are the *cause* of thunderstorms. Of course, this is not true. In 1752, Benjamin Franklin showed that lightning is a huge spark produced by static electricity. When you scuff your shoes along a fuzzy carpet then touch someone, a small spark jumps from your finger and you both get a shock. Unlike the electricity that flows through a living-room lamp, static electricity does not flow evenly. It forms in an object—you, for instance—then, when a big enough charge builds up, the electricity suddenly jumps from the object as a spark. The more you scuff your feet, the greater electric charge you build up, and the greater the spark during *discharge* (when the electricity leaves your body).

Although weather scientists still have much more to learn about lightning, generally they know what happens when lightning flashes out of a cloud. Water droplets inside a thunder cloud are torn apart by the strong updrafts and downdrafts inside the cloud. As the droplets are torn apart they become electrically charged. It is as if the droplets were scuffing their "feet" on a carpet of wind. As the diagram shows, the rubbing action causes certain parts of the cloud to build up a positive charge (+) while other parts build up a negative charge (−). When enough static electricity has built up in the cloud a discharge takes place and you see a lightning flash. The lightning may jump from one part of the cloud to another, from the cloud to the ground, or from one cloud to another cloud. Scientists believe that lightning is most active in those parts of a cloud where the temperature is below freezing.

Where there is lightning, there is bound to be thunder. The temperature of a lightning bolt is about 50,000°F. This intense heat causes the air around the lightning bolt to expand suddenly, which you hear as a sharp *CRACK!* if the storm is right overhead. You also hear thunder as a booming and rumbling. Since thunder is produced all along the path of the lightning stroke, the sound coming from the most distant part of the stroke takes longer to reach you than the sound coming from the closest part of the stroke. So there are many sounds all mixed up. Because light travels faster than sound, you always see the lightning flash before you hear the thunder—and this gives you a way of finding out how far away a thunderstorm is ■



A lightning stroke is a giant spark that may jump from one cloud to another, from a cloud to the ground, or from one part of a cloud to another part of the same cloud.

PROJECT

You will need a stop watch, or a watch with a sweep second hand. During a thunderstorm wait for a lightning flash then count the number of seconds it takes before you hear the thunder clap. Divide the number of seconds by five and the answer will tell you how many miles away the storm is. For example, if you counted 15 seconds between lightning flash and thunder clap (15 ÷ 5 = 3), then the storm is about three miles away.

LIGHTNING SAFETY RULES

DON'T go outdoors during thunderstorms.

DON'T go near open doors or windows, fireplaces, stoves, or electrical equipment such as radios, TV's, lamps, or other things that plug into electrical outlets.

DO look for shelter if you are outdoors—not only to keep dry but to avoid lightning. The larger the building, the better. Large metal or metal-frame buildings are best.

If you are on a hike, look for shelter in a cave, or at the foot of a cliff, or in a deep valley or canyon. If you are in a field, lie down in a hole. If you are in the woods, don't stand under the tallest trees to keep dry; instead, stand under short trees that are surrounded by tall trees.

If you are in a field with only a few trees, crouch down in the open, away from trees at a distance greater than the height of the nearest tree.

DON'T handle metal things such as fishing rods or golf clubs.

DON'T take shelter from the rain near isolated trees, wire fences, or in small exposed sheds. Stay away from hilltops.

DON'T go into the water or into small boats during a thunderstorm.

DO stay in your automobile during a thunderstorm. Automobiles offer excellent protection from lightning.

PROJECT

Check up on the causes of thunderstorms where you live. If the weatherman on TV or radio mentions that a "front" is in the area, then the front is probably the cause of the thunderstorm. If you live in a mountainous region, then moist, warm air crossing the mountains may cause the storm. A storm may also be set off by local heating on a hot summer day. These storms occur mostly in the afternoon. Frontal thunderstorms can occur almost any time of the day or night.

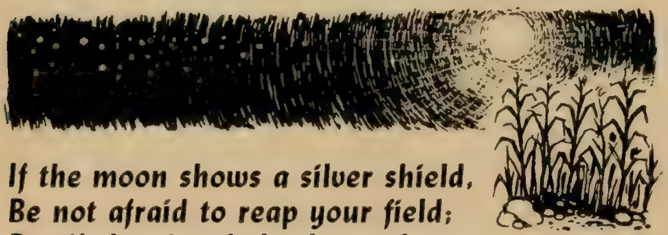
Keep a record of the different types of storms in your area to find out which type is most common during the spring, the summer, the fall.

WEATHER SAYINGS

How true are they?

■ Long before weather forecasting became a science, farmers, sailors, and others had to be keen observers of clouds and other signs of change in the weather. Sometimes their lives depended on their ability to tell when a storm was in the making.

Many of the weather sayings that have found their way into common use over the years have been based on superstition; others, however, have been based on observations of winds and cloud formations. Meteorologists have tested many of the sayings and have found that some have a sound scientific basis. Here are four:



If the moon shows a silver shield,
Be not afraid to reap your field;
But if she rises haloed round,
Soon we'll tread on deluged (rainy) ground.

Halos around the moon or sun are caused by light reflecting off ice crystal clouds that form in layers (cirrostratus clouds). These clouds often are signs of approaching rainy weather.

Sky red in the morning
Is a sailor's sure warning;
Sky red toward night
Is a sailor's delight.

Dust and other tiny particles in the air scatter the sun's light and make the sky appear colorful. During such times the air is usually dry. A red sky at sunrise means that generally fair weather is east of the ship and that foul weather might follow since weather generally moves from west to east. But a red sky at sunset means that the air west of the ship is relatively dry. Therefore, expect improved or fair weather. This saying applies to weather over land, also.

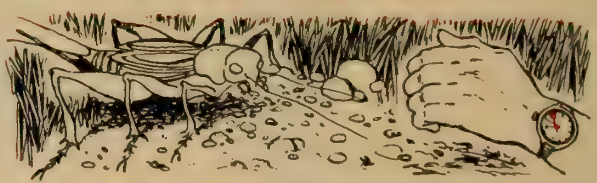
A veering wind, fair weather;
A backing wind, foul weather.

When the wind backs and the
weather glass (barometer) falls,
Then be on your guard against
gales and squalls.

"Veering" winds change direction clockwise. For example, a wind blowing out of the south may shift direction until it is blowing out of the northwest. Such a shift generally brings fair or improved weather, because it means that the low-pressure system where you are is moving eastward and is likely to be replaced by a high-pressure system coming out of the west. Generally, high-pressure systems mean fair weather; low-pressure systems mean foul weather.

"Backing" winds shift in the opposite way. Wind blowing out of the southwest becomes a backing wind if it shifts counterclockwise until it is blowing out of the east. These winds usually bring a low-pressure system and foul weather.—GERALD L. SHAK

INVESTIGATION



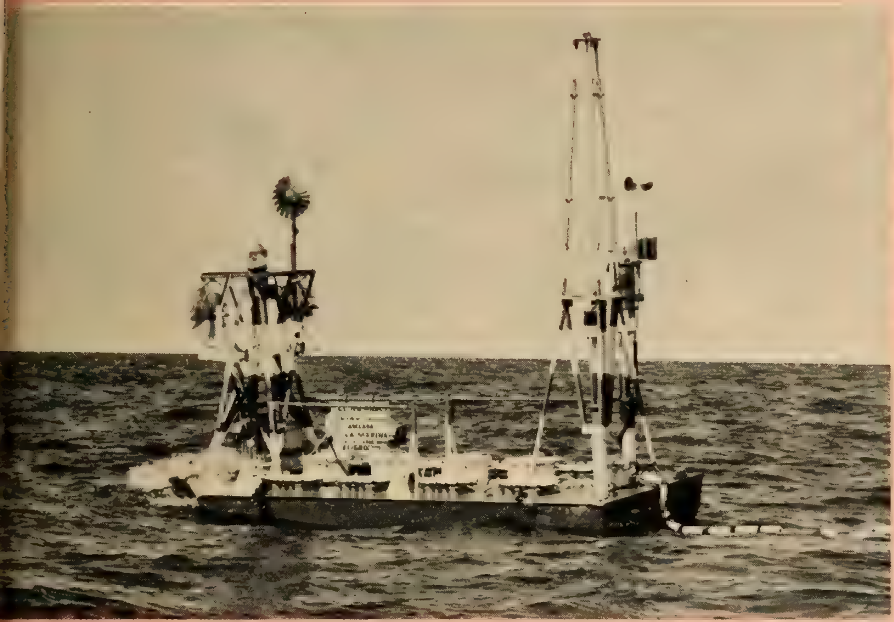
Crickets can be used as natural thermometers. How rapidly or slowly a cricket chirps depends on the temperature of the air. Sneak up on a cricket and count the number of times it chirps in 14 seconds. Make at least two counts; five would be better. Say that the first time you count 34 chirps, and the second time you count 36 chirps. The average is 35. Add whatever number you count (35 in this case) to 40 to find out what the temperature is in Fahrenheit degrees.

a new look at weather

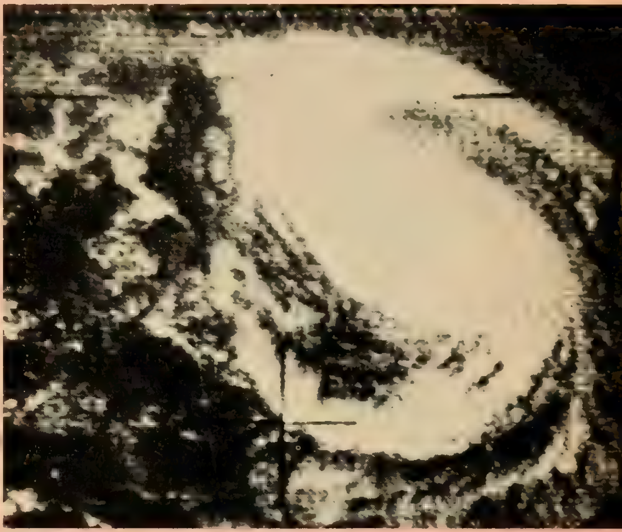
■ Scattered over the globe are more than 10,000 weather reporting stations. While some are operated by people, others are complex instrument packages that automatically send information from the middle of the ocean or from a wind-swept mountain peak. Still other weather information is automatically radioed to earth from satellites, rockets, and high-altitude balloons.

These millions of bits of information about wind speed and direction, relative humidity, temperature, atmospheric pressure, radiation, and so on must be sorted and arranged in such a way that forecasters can know when to issue a storm warning, or announce "Fair and warmer."

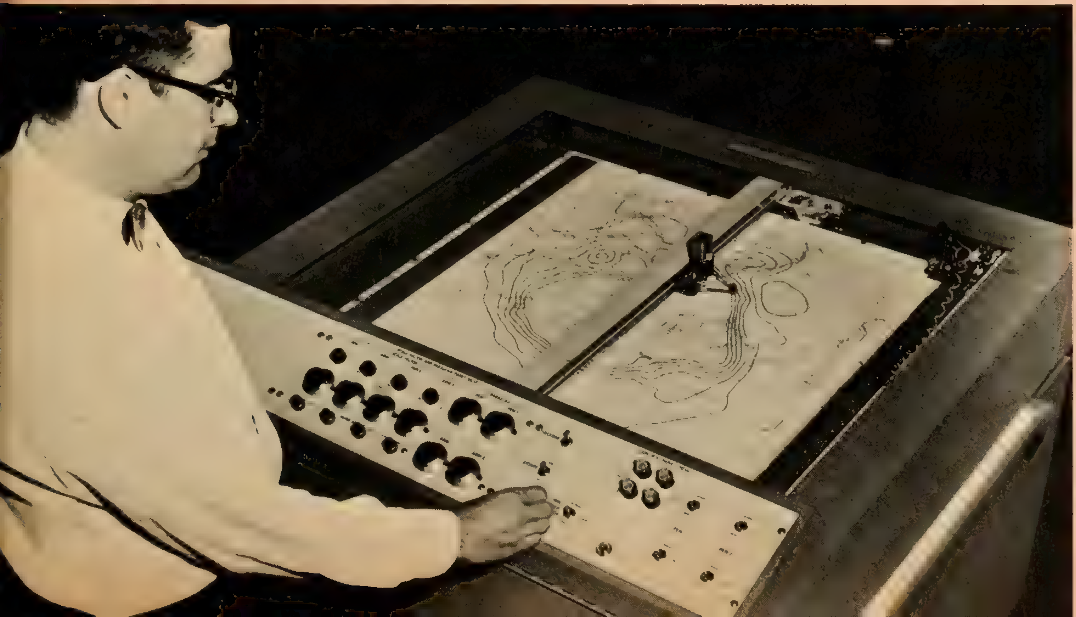
Pictured on this page are some of the newer machines and methods that are helping meteorologists unscramble what is perhaps the most complex puzzle in nature—the weather—Gerald L. Shak



NOMAD I weather station is one of many automatic stations that makes observations in remote parts of the world. This one, designed by the Navy to operate at sea, measures wind direction and speed, air pressure, air and water temperature, and has a trial attachment for measuring solar radiation. NOMAD I radios its findings to a nearby land weather station.



This photograph of a hurricane was made by a TIROS satellite and shows the typical hurricane cloud banding. Such photographs, televised by a satellite to ground weather stations, can provide early warnings that a storm is developing. The satellite can also report on the storm's progress. The area covered by the hurricane here is about 300 miles across.



Wiggly lines (called isobars) are being drawn on this weather map of the Northern Hemisphere by a computer. After information about air pressure from weather stations around the world has been fed into the computer, and sorted out by the machine, the computer draws the map in three minutes. Drawing it by hand takes more than an hour.

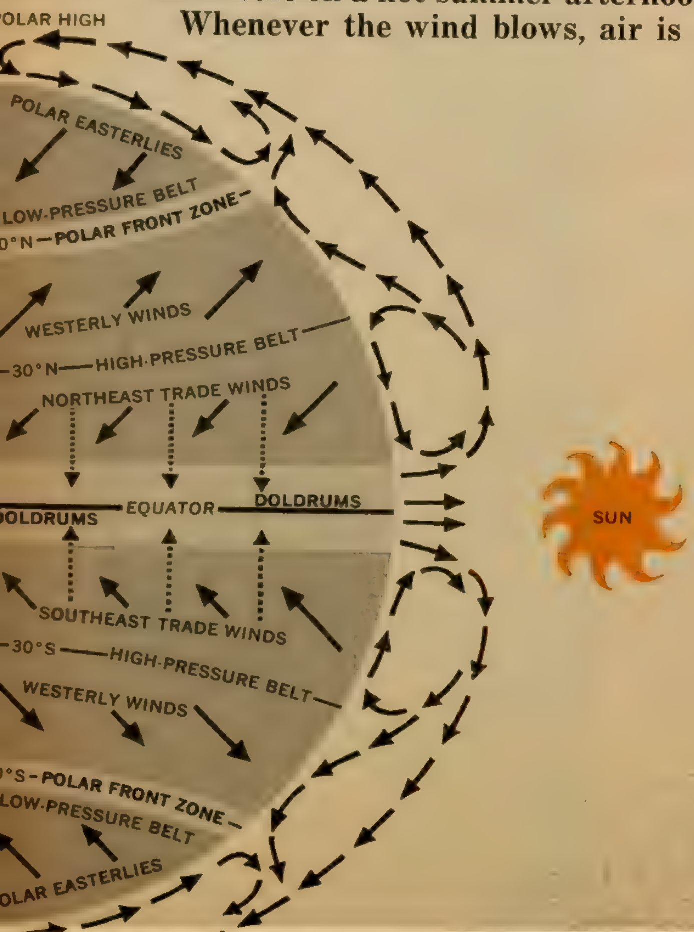
nature and science | WALL CHART April 4, 1966

Where do the winds come from?

by Roy A. Gallant

■ Like the sea, our ocean of air is always in motion. There are *prevailing* winds, like the belts of westerlies and the belts of trade winds, that blow steadily around the globe day and night. Also, there are *local* winds, like a cooling sea breeze on a hot summer afternoon.

Whenever the wind blows, air is moving from a place where there is more air to a place where there is less air—that is, from an area of high pressure to an area of low pressure *(see diagram 1)*. The diagram below shows a world view of the air piling up in some places and forming high-pressure belts. The flow of air from areas of high pressure to areas of low pressure sets up the major wind belts ■

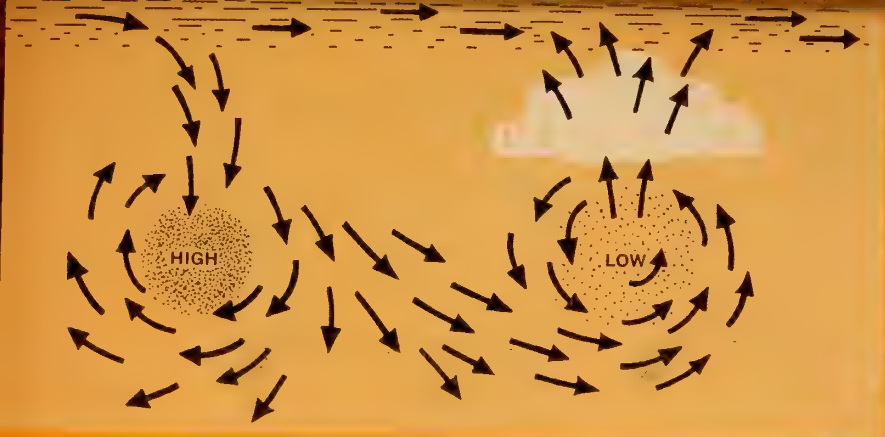

OLAR HIGH
POLAR EASTERLIES
LOW-PRESSURE BELT
0°N—POLAR FRONT ZONE
WESTERLY WINDS
30°N—HIGH-PRESSURE BELT
NORTHEAST TRADE WINDS
OLDRUMS
EQUATOR
DOLDRUMS
SOUTHEAST TRADE WINDS
30°S—HIGH-PRESSURE BELT
WESTERLY WINDS
°S-POLAR FRONT ZONE
LOW-PRESSURE BELT
OLAR EASTERLIES
SUN

WINDS THAT BLOW AROUND THE WORLD

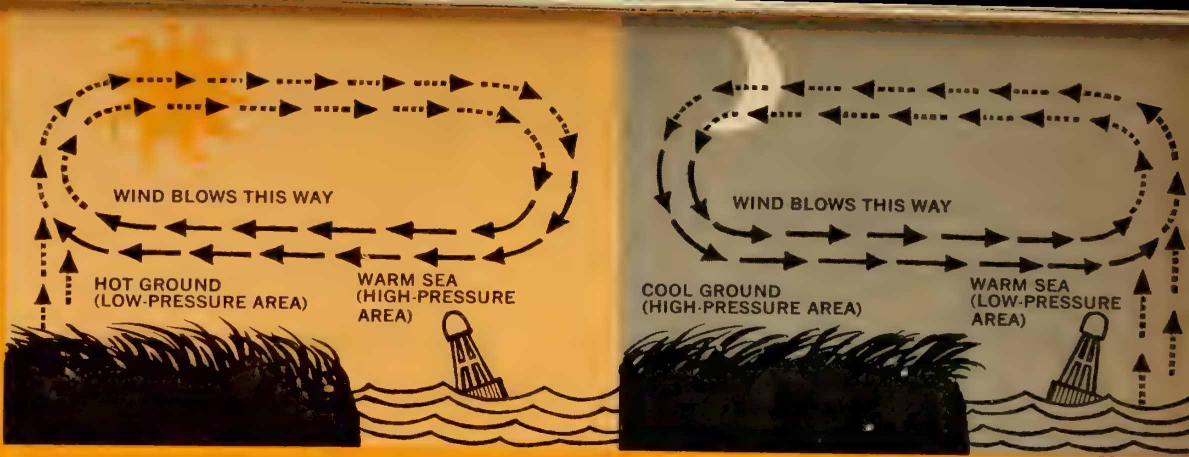
The sun is the storehouse of energy that keeps the earth's air in motion. Sunlight heats the air at the Equator more than it heats the air at other latitudes. This warm air rises, making a belt of "thin," low-pressure air all along the Equator. Some of this rising low-pressure air flows northward and some southward, toward the poles. At about 30°N and 30°S some of the air, now heavy because it has been cooled, sinks down to the ground, where it tends to pile up and form a high-pressure belt.

If the earth were not spinning like a top, some of this dense high-pressure air would flow *straight* back toward the Equator *(see dotted lines in diagram)*, and some would flow *straight* toward the poles. But because the earth is spinning, the winds blowing toward the Equator (called the *trade* winds) blow at a slant. So do winds that blow toward the poles (*westerlies*).

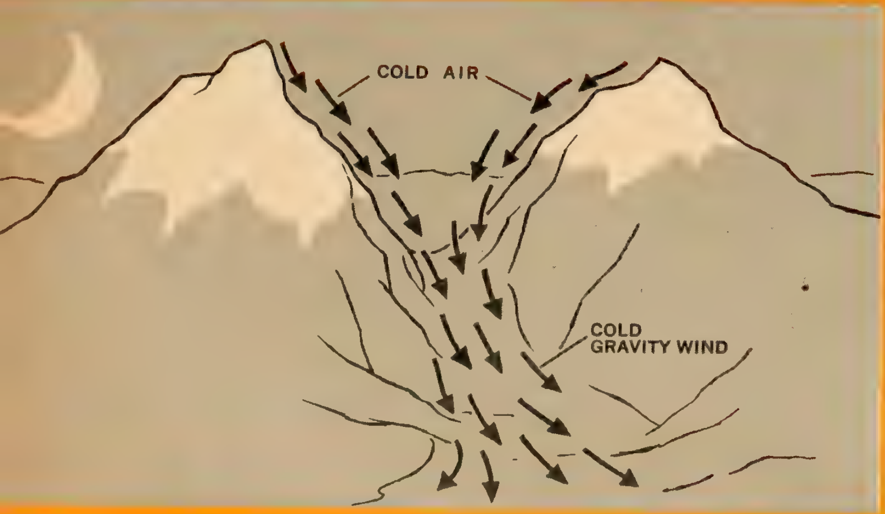
At about 60°N and 60°S air flowing toward the Equator from the poles meets the westerlies air, which is moving in the opposite direction. The warmer westerlies air is lifted and rises, as shown. This process forms a low-pressure belt called the *polar front* zone. At the poles, the cold, heavy air tends to sink and form two high-pressure polar caps. As with local winds, the world-girdling prevailing winds flow from regions of high pressure to regions of low pressure.



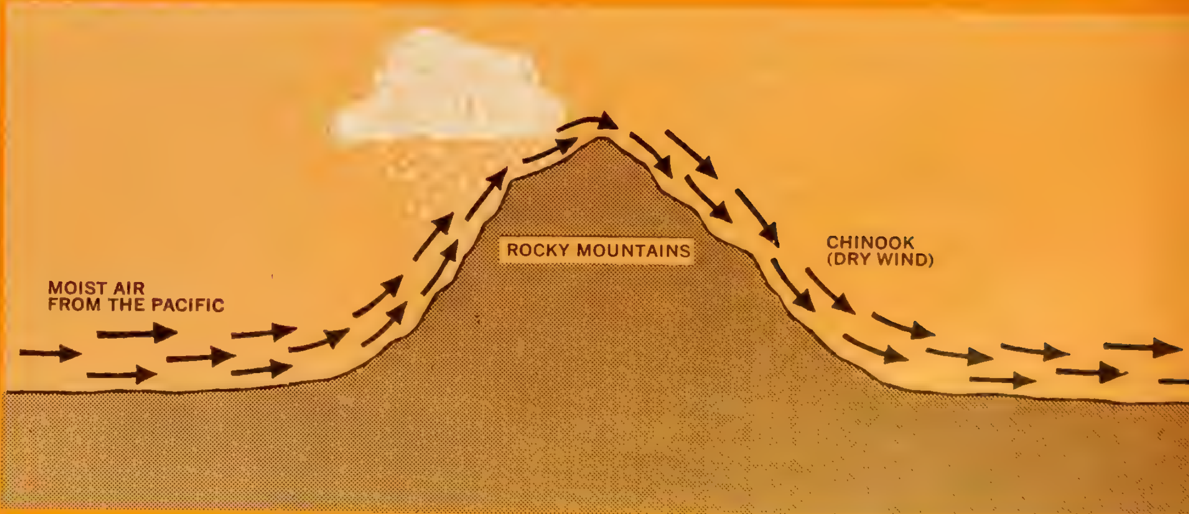
1. A mass of cool air contains a greater number of air particles than a mass of warm air filling the same space. Because there are more particles of air bouncing off each other and flying about in a mass of cold air, the air pressure is higher than the pressure in a mass of warmer air. Because cool air weighs more than warm air, cool air tends to sink while warm air tends to rise. As the diagram shows, air (the wind) flows from a region where the air pressure is high to a region of lower pressure.


WIND BLOWS THIS WAY
HOT GROUND (LOW-PRESSURE AREA)
WARM SEA (HIGH-PRESSURE AREA)
WIND BLOWS THIS WAY
COOL GROUND (HIGH-PRESSURE AREA)
WARM SEA (LOW-PRESSURE AREA)

2. On a hot day, air over the land is heated and rises, forming a local low-pressure area. Cooler (high-pressure) air over the sea flows toward the land, causing a cooling sea breeze. At night, just the opposite happens. The ground cools much faster than the sea does. Over the land there is now a high-pressure area compared with the low-pressure area over the warmer sea. As a result, at night, the wind blows from the land out to sea.


COLD AIR
COLD GRAVITY WIND

3. At night, the air high up on mountain slopes cools more quickly than air down near the base of the mountain. Because the cooler air is heavier, it sinks along the slope *(see arrows)*, producing a mountain wind called a gravity wind. Mountain winds may reach speeds up to 50 miles an hour or more.


MOIST AIR FROM THE PACIFIC
ROCKY MOUNTAINS
CHINOOK (DRY WIND)

4. The westerlies, which blow from west to east, come in off the Pacific carrying lots of moisture. As this air flows up the western slopes of the Rocky Mountains during its journey east, it is cooled and loses much of its moisture (water vapor). The moisture forms clouds which may cause rain or snow. Now dry, the cold westerly air sweeps down the mountain rapidly and its temperature rises quickly. Following the arrival of this down-the-slope air, the temperature of the air near the base of the mountain may rise as much as 30°F within a few minutes. This dry wind is called a "chinook," meaning "snow-eater," because it absorbs large amounts of moisture as it sweeps along.

MAKE YOUR OWN WEATHER STATION

by Gerald L. Shak

By building four simple weather instruments and using them every day, you can get off to a good start to becoming your own weatherman.

■ To predict the weather, meteorologists must observe today's weather and compare it with yesterday's weather and that of the day before. There are many changes the meteorologist looks for, and the changes are clues to future changes in the weather. The amount of clouds, the air temperature and amount of moisture in the air, air pressure changes, and the direction and speed of the wind are all important clues, as you will find if you build your own weather station and keep records day by day.

The instruments you will need to measure wind direction, air pressure changes, humidity, and the amount of rainfall all can be made out of cans, wood, nails, screws, cardboard and other materials you probably have around the house ■

MEASURING THE WIND

When the weatherman says that a south wind is blowing, he means that the wind is blowing *from* the south, not toward the south. When you feel the wind blowing directly into your face, then the direction in which you are facing is the direction of the wind. The wind vane, which measures wind direction, is probably the oldest of all weather instruments.

You don't need a complex instrument to measure the speed of the wind; you can estimate wind speed with the aid of the Beaufort scale on this page. By looking around and observing the motions of leaves on trees, tree branches, chimney smoke, and so on, you can estimate wind speed fairly accurately.

BEAUFORT SCALE OF WIND SPEED

WIND SPEED IN MILES PER HOUR	WHAT TO LOOK FOR
Less than 1	Smoke rises straight up. Leaves on the trees and on the ground are motionless.
1-3	Smoke drift shows wind direction. Tree leaves barely move. Wind vane is not moved.
4-7	Leaves rustle slightly. Wind is felt on the face. Wind vanes are moved by wind.
8-12	Leaves and twigs move. Loose paper and dust are raised from the ground.
13-18	Small branches are moved. Dust and paper are raised and driven along.
19-24	Small trees sway. Large branches move. Dust clouds are raised.
25-31	Large branches move continuously. Wind begins to whistle. Umbrellas are used with difficulty.
32-38	Whole trees are in motion. Walking is difficult.

How To Make a Wind Vane

You can make a vane out of a thin wooden rod or dowel ½ inch in diameter and 15 inches long. The arrowhead and fin can be made of metal from a large fruit juice can. Remove the ends of the can and cut the can down the side with tin snips, then flatten the metal with a hammer. (Do this carefully or you may cut yourself.) You can cut the fin into a plain or fancy shape, but do your best to keep it about 4 inches deep by 6 inches long (*see diagram*).

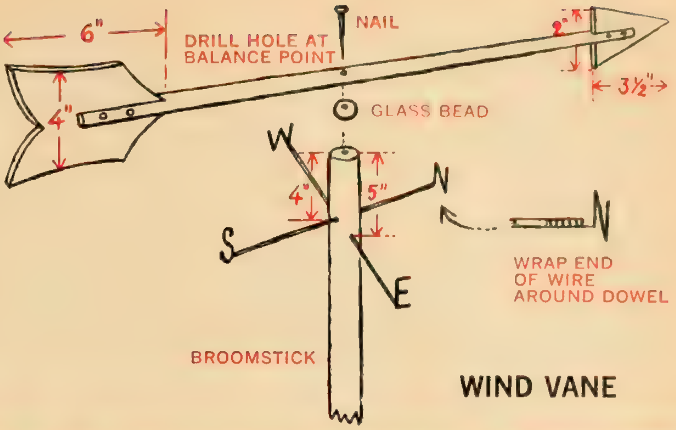
Use metal from the same tin can to shape an arrowhead. Fold the tin to double the thickness of the metal, then hammer it flat. (The double thickness adds weight to the arrowhead so that the vane will be better balanced.) Cut the arrowhead to the dimensions shown in the diagram.

With a small saw, cut a 1½-inch slot in one end of the dowel to hold the fin. Cut a ¾-inch slot in the other end for the arrowhead. Drill four small holes through the dowel, as shown in the diagram. Fit the fin and arrowhead in place, then drill matching holes in the metal. Nuts and bolts inserted through these holes will hold the metal firmly in place.

Balance the wind vane shaft on a knife edge to find the balance point. If the balance point is too close to the fin, wind some heavy wire (such as solder) around the shaft near the arrowhead. This will shift the balance point closer to the middle of the shaft. At the balance point, drill a small hole through the rod, as shown. Stick a loose fitting nail through the dowel, using a glass bead as shown, and hammer the nail into the end of a broomstick or long pole. *Make sure the vane swings around freely.*

Drill two ¼-inch holes at right angles to each other—one 4 inches from the top of the stick and the other 5 inches from the top. Insert ¼-inch dowels, about 8 inches long, through the holes and glue the dowels in place. Shape the letters N, S, E, and W out of heavy wire and attach them to the ends of the dowels.

The wind vane should be set up in a large open area away from large buildings and trees. The next best location would be the roof of a building. If this is not possible, either, then you'll just have to do some exploring until you find a place where the wind direction is not changed too much by buildings or trees. When you fix your wind vane in place, use a compass to point the "N" in the direction of north.



WIND VANE

HUMIDITY AND TEMPERATURE

The temperature of the air and the amount of water vapor (moisture) in the air influence the way we dress. To the meteorologist, temperature and humidity may be important signs of changing weather.

When the meteorologist talks about the amount of "moisture" in the air, he uses the term *relative humidity*. On days when the relative humidity is high the air feels damp and "sticky." To measure relative humidity the meteorologist finds out how quickly water evaporates from the surface of the bulb of a thermometer. He uses a psychrometer—an instrument made out of two thermometers mounted side by side. One of the thermometers has a cloth wick that keeps the bulb wet, and is called a "wet-bulb" thermometer. The other one is called a "dry-bulb" thermometer. To find out what the relative humidity is, you must read both thermometers at the same time.

How To Make a Psychrometer

Mount two *identical* thermometers side by side on a board as shown in the diagram. You can make a wick for the wet-bulb thermometer from a small piece of white shoe string or a small piece of white, thin, cotton material. Slip it over the end of the bulb and tie it in place with white thread.

Before reading the wet-bulb thermometer, wet the wick with clear water from an eye dropper. Or, if the wick is long enough, one end can rest in a small plastic container of water (*see diagram*). If you wet the wick with a dropper, allow enough time for the air to *evaporate the water* from the wick before you make your reading. Watch the temperature drop, then read both thermometers when the fluid in the wet-bulb thermometer stops going lower. Next use the Relative Humidity Table to find out what the relative humidity is.

For example, say that your dry-bulb thermometer reads 70°F and your wet-bulb reads 62°F. The difference in temperature is 8°F (70 —62 = 8). Read down the left-hand side of the table until you find 70, then read across the 70 line

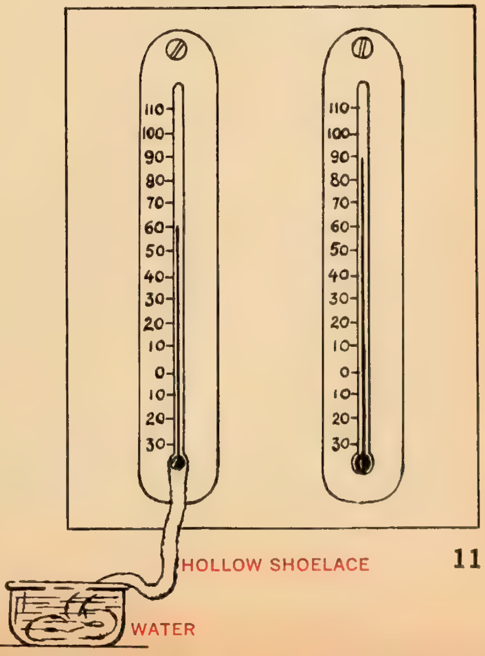
(Continued on the next page)

RELATIVE HUMIDITY TABLE

DIFFERENCE BETWEEN DRY BULB AND WET BULB TEMPERATURES IN DEGREES FAHRENHEIT

DRY-BULB TEMPERATURE DEGREES FAHRENHEIT	1	2	3	4	5	6	7	8	9	10	11	12	14	16	18	20	22	24	26	28	30	32	34
10	78	56	34	13																			
15	82	64	46	29	11																		
20	85	70	55	40	26	12																	
25	87	74	62	49	37	25	13	1															
30	89	78	67	56	46	36	26	16	6														
35	91	81	72	63	54	45	36	27	19	10	2												
40	92	83	75	68	60	52	45	37	29	22	15	7											
45	93	86	78	71	64	57	51	44	38	31	25	18	6										
50	93	87	80	74	67	61	55	49	43	38	32	27	16	5									
55	94	88	82	76	70	65	59	54	49	43	38	33	23	14	5								
60	94	89	83	78	73	68	63	58	53	48	43	39	30	21	13	5							
65	95	90	85	80	75	70	66	61	56	52	48	44	35	27	20	12	5						
70	95	90	86	81	77	72	68	64	59	55	51	48	40	33	25	19	12	6					
75	96	91	86	82	78	74	70	66	62	58	54	51	44	37	30	24	18	12	7	1			
80	96	91	87	83	79	75	72	68	64	61	57	54	47	41	35	29	23	18	12	7	3		
90	96	92	89	85	81	78	74	71	68	65	61	58	52	47	41	36	31	26	22	17	13	9	5
100	96	93	89	86	83	80	77	73	70	68	65	62	56	51	46	41	37	33	28	24	21	17	13

PSYCHROMETER



until you come to the 8 column. The relative humidity is 64 per cent. This shows that the air contains only 64 per cent of the moisture (*water vapor*) that it can hold at a certain temperature and pressure. Water vapor is water in the form of a gas in the atmosphere.

Your psychrometer should be located in the shade. The best place is the north side of a building if you want to leave it out in the open, or in a ventilated shelter. It is important that the wick and water remain clean, and that the air moves freely around the thermometers.

INVESTIGATION

Measure the *diurnal* (daily) change in relative humidity. Take readings of both thermometers about mid-afternoon, and again at night before you go to bed. Do this for several days. Is there a regular pattern of change?

Which winds bring the driest air (lowest relative humidity)? Which winds bring air of the highest relative humidity?

MEASURING AIR PRESSURE

The air around you is constantly pressing against your body and against the ground, although you can't feel it. Because the air is constantly moving about, its "pressing force" or pressure, at any one location is nearly always changing. Air pressure never stays the same for very long.

The meteorologist measures air pressure with an instrument called a *barometer (see diagram).* A rising barometer (which means rising air pressure) accompanied by winds shifting from southerly to westerly may mean a change from bad weather to fair weather.

How To Build a Barometer

You can make a very simple barometer from a thermos bottle and some mineral oil. It will not give you an accurate measurement of air pressure, but it will show the *changes* in pressure.

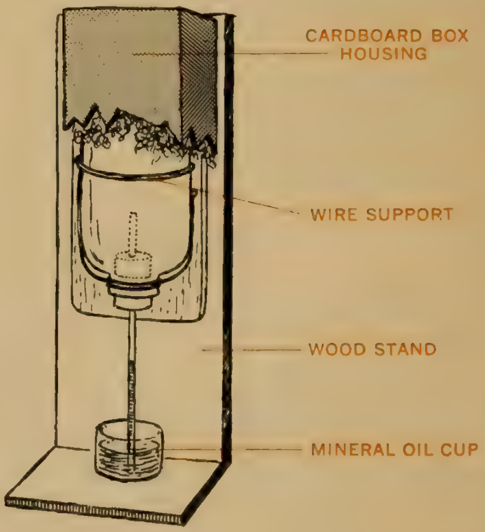
Remove the cork from a pint-size thermos bottle. Bore a hole in the cork and fit a clear stiff plastic or glass tube about 10 inches long into the cork. Place the cork into the thermos as shown in the diagram. Now seal the cork and the edges around the tube and thermos with dripping candle wax or a heavy coating of an all-purpose glue. This will keep air from seeping into or out of the thermos.

Mount the thermos upside down on a wooden stand so that the end of the tube is about ¼ inch from the base of the stand. Wrap the thermos in newspaper or rock wool and fit a cardboard box snugly around it. This will help insulate it from changes in temperature. If it is not protected from temperature changes, it will act more like a thermometer than a barometer.

Place a very small cup under the tube and fill the cup with colored mineral oil. (You can use food dye to color the oil.) You should not fill the cup until the air pressure is low (below 29.90 inches). The weather news on radio or TV nearly always gives the barometric pressure.

Whenever the air pressure rises, the mineral oil will be forced up the tube. Be sure to keep enough mineral oil in the cup to cover the bottom of the tube. You do not have to keep the barometer outdoors. It will work just as well in the house, because the atmospheric pressure outside is similar to the pressure indoors. If you keep daily records of the air pressure, you can note when the barometer was rising, falling, or was steady.

BAROMETER



INVESTIGATION

Relate wind direction and speed with changes in air pressure. When the barometer is rising or falling rapidly, notice what changes are taking place outside. Does fair weather follow a rising barometer? You will find that the wind *usually* blows from a certain direction where you live. What does the barometer do when the wind shifts in direction?

MEASURING RAINFALL

Because of the importance of rain to farmers, in causing floods, and as a source of drinking water, the meteorologist measures the amount of rainfall. The rainfall records he keeps help the farmer decide when he must irrigate his fields and help the engineer control the flow of water over dams to prevent floods.

The amount of rain that falls during a storm is measured by the depth of the water on a surface that does not absorb water. A tin can, properly placed outdoors, may be used to catch rain. Then the depth of rain water in the can may be measured with a *thin* stick, so that the level of the water is not increased by the stick. But it is hard to get an accurate measurement this way. The meteorologist wants to know to a fraction of an inch how much rain fell. To get a fine measurement you must magnify the depth of your rain catch.

How To Make a Rain Gage

You will need one large fruit juice can about 8 or 9 inches high and 4 to 5 inches in diameter. Remove the top of the can and mount the can firmly, as shown in the diagram. When you use your gage, be sure to place it out in the open in a well exposed area, not up against a shed. To prevent the gage from being blown over, loop rings of clothes hanger wire around the post and collecting can. You can fasten the wire to the post with heavy staples. The wire loops should be just snug enough so that you can remove the can easily.

If it rains during the night, some of the water you have collected will evaporate before you make a measurement in the morning. You can stop a lot of evaporation by fitting a funnel into the can (*see diagram*). The top of the funnel must be the same diameter as the top of the can. In a hardware store you can buy a funnel made of soft plastic and cut a little bit of the rim off so that the funnel fits the can snugly. To keep the funnel from slipping into the can, or from being blown away, tape the edge of the funnel to the can with strips of masking tape. This completes the rain gage, but now you need a measuring jar.

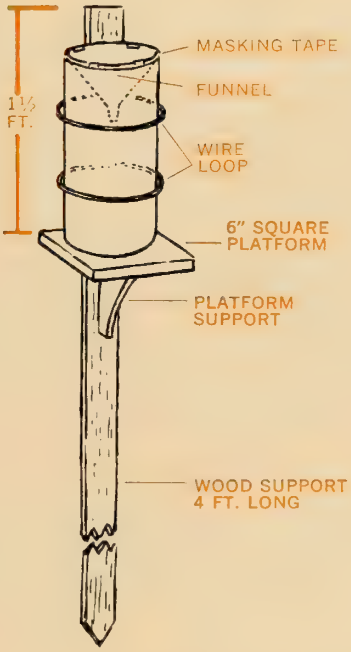
You'll have to get a tall, slender, straight glass or jar with a flat bottom, like an olive jar. The container must be no more than 1 or 1½ inches wide to give an accurate measurement of the amount of rain that fell.

Remove the plastic funnel and pour *exactly* one inch of water into your rain gage can. Now pour the water into the slender container. With fingernail polish and one bristle of a paint brush, mark a very thin line on the container at the water mark. This mark shows one inch of rainfall. Now mark off 10 equally spaced units from the bottom of the container to the 1-inch mark. Label the top mark "1 in."

If you wish, you can mark your measuring container to a depth of two inches. Just pour two inches of water in your collecting can and go through the measuring steps again.

Put the rain gage out in the open and wait for the first rainfall. When you read your other instruments, remove the gage from its wooden base, pour the water into the measuring glass, and read off the amount of rainfall to the nearest tenth of an inch. If more rain has fallen than will fit into the measuring glass, measure the water in two or more smaller quantities and add them together to get the total rainfall.

RAIN GAGE



Here are some books about the weather. They go into more detail about winds, instruments, and forecasting than the articles in this issue do. Books with an (E) = easy, (M) = medium, (A) = advanced: **(E) Instruments Used in Weather Observing,** and **Lightning,** U.S. Government Printing Office, Washington, D.C. 20402, each 5 cents; **(E) The Wind,** by Jeanne Bendick, Rand McNally & Co., New York, 1964, $2.95; **(E-M) Weather Forecastry as a Hobby,** by Robert Wells, C. S. Hammond & Co., Inc., Maplewood, N.J., 1962, $.69 (paper); **(M) Exploring the Weather,** by Roy A. Gallant, Garden City Books, Garden City, N.Y., 1957, $3.25; **(M) 1001 Questions Answered about the Weather,** by Frank H. Forrester, Dodd, Mead & Co., New York, 1957, $6; **(A) Weather: Air Masses, Clouds, Rainfall, Storms, Weather Maps, Climate,** Simon and Schuster (Golden Nature Guide), 1957, $1 (paper); **(A) Weather for a Hobby, a Guide to the Construction and Use of Weather Instruments Intended for Amateurs,** Rev. ed., Dodd, Mead & Co., New York, 1956, $3; **(A) Weather,** Life Science Library, Time Inc., New York, 1965, $3.95.

CHECKING UP ON THE WEATHER

Most people just talk about the weather. Here are some things you can DO about it.

Once you have built some weather instruments (see page 10) you will find dozens of questions to ask about the weather. But asking questions is only part of the fun. Finding answers on your own is more rewarding.

On these two pages are three investigations that you can carry out to find out certain things about weather patterns where you live. When you make weather observations each day you should try to make them at about the same hour—7:00 A.M. local time is when thousands of U.S. Weather Bureau observers read their instruments.

—CHARLES KNUDSEN

PROJECTS

The next time it hails collect some hail stones and carefully break them apart. If you could cut them in two, that would be even better. Examine their insides with a magnifying glass. What kinds of patterns do you see? Do the patterns give you a clue about how hail stones are formed?

Often there are scattered clouds at different heights. Some morning or afternoon watch the clouds to find out which way they are being blown by the wind. Do all of the clouds move in the same direction? Do you ever see lower clouds blowing in one direction and higher clouds blowing in a different direction?

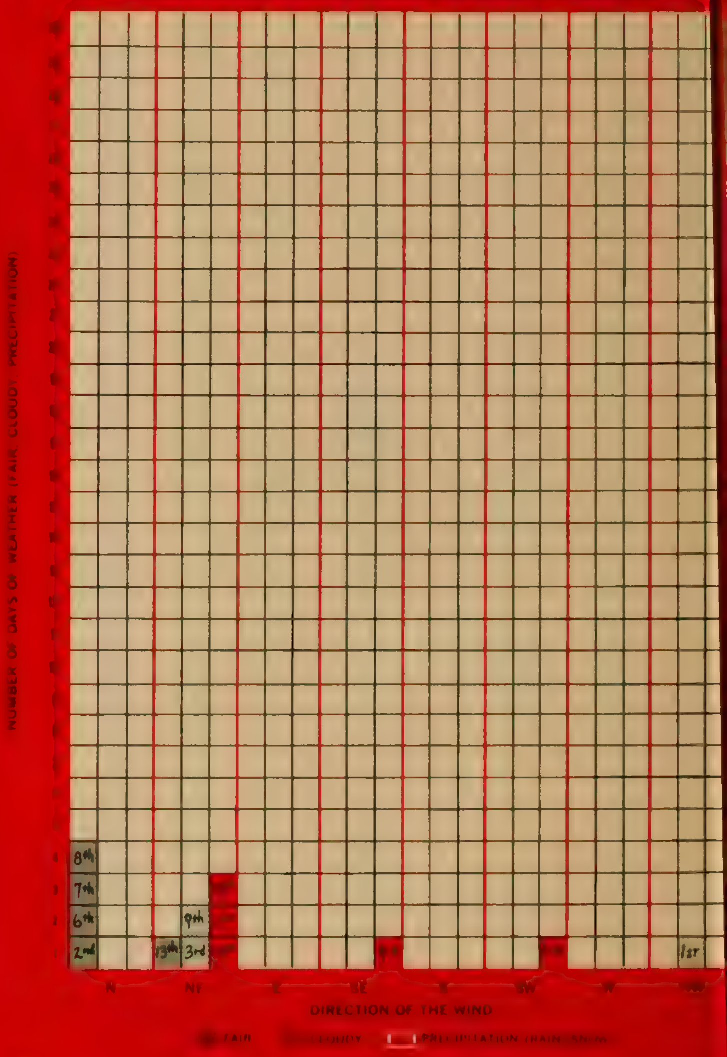
INVESTIGATION 1

How often do certain winds bring certain kinds of weather? Look for different patterns month by month.

The graph below will help you get started with this investigati
The numbers 1-30 in the left-hand column show the number
days during a month that you had certain kinds of weather—f
cloudy, or precipitation (rain, snow, hail, or sleet). Notice that
Weather Station X, on the first day of the month the wind was
of the northwest and the weather was cloudy. Then, on the sec
day the wind was out of the north and it was fair. On the third d
the wind shifted to the northeast and it was cloudy, and so
through the first 13 days of the month.

When you complete a graph for one month you will have so
idea of the kinds of winds that bring certain kinds of weather
your area. For example, you might be able to conclude that,
the month of April, south winds brought cloudy and showe
weather. If you keep such graphs month by month you will
out something about typical weather for each month for your ar

OBSERVATIONS MADE AT WEATHER STATION X, U.S.A. 7:00 A.M.



GRAPH FOR (*month*), 1966

INVESTIGATION 2

Does a changing wind direction bring a change in temperature?

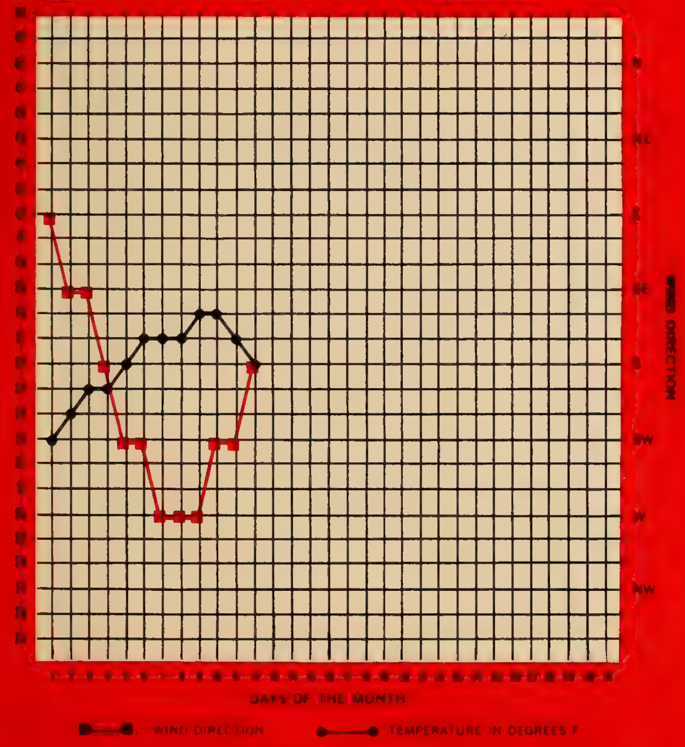
Here is another graph that will help you get started with a wind direction and temperature investigation. This one is a double graph. When you complete it for one month you probably will find some interesting patterns made by the temperature line crossing the wind direction line.

Along the bottom line of the graph are the days of the month. Along the left-hand edge is the temperature, beginning at 25°F and stopping at 50°F. Depending on where you live, you might want to change the temperature range, say from 15° to 45° or so, or from 50° to 80°. Along the right-hand edge of the graph you will find the wind directions.

Pretend that we are at Weather Station X again, and have filled in the temperature for the first 12 days of the month. As you can see, the temperature rose on the second and third days, remained the same on the fourth day, then rose some more, and so on. In the meantime, the wind direction shifted gradually from the east on the first day to southeast on the second and third days, then on the fourth day it blew out of the south. In other words, a rise in temperature came with a shift in wind from the east to the south. Then, later in the month, just the opposite happened. As the wind shifted back from the west to the south again, there was a fall in temperature.

Find out which winds bring rising temperatures and which ones bring falling temperatures where you live. If you keep records month by month you will see some interesting patterns.

OBSERVATIONS MADE AT WEATHER STATION X, U.S.A. 7:00 A.M.



GRAPH FOR (*month*), 1966

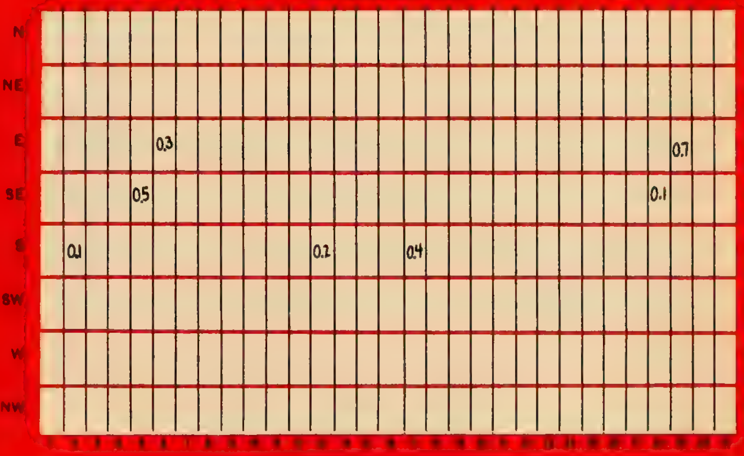
INVESTIGATION 3

Which winds bring the most rainfall? Which winds bring the least?

For a month keep a day-by-day record of how much rain falls, and the wind direction at the time of the rain. (Even though it may be raining at the time, make your rainfall measurement at about 7:00 A.M.) As the table shows, Weather Station X had 0.1 inch of rain on the second day of the month, and the wind was out of the south. On the fifth day of the month a half inch (0.5) of rain fell, and the wind was out of the southeast. At the end of the month the meteorologist added the number of inches of rain that fell when an east wind was blowing—1.0 inch—and entered this figure on a bar graph. Southeast winds brought a total of 0.6 inch during the month, and south winds brought a total of 0.7 inches of rain for the month.

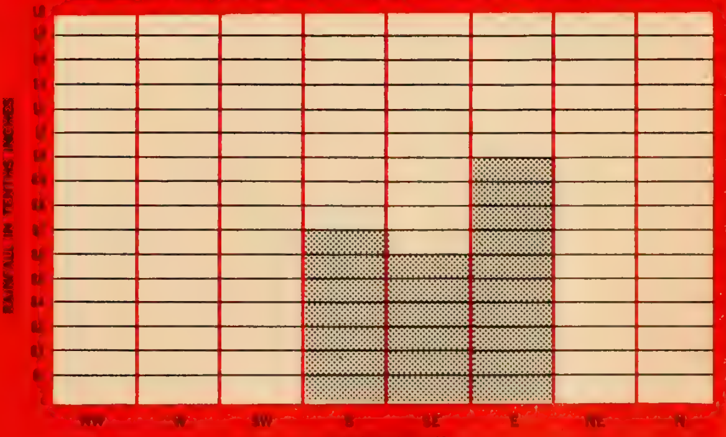
Try keeping such records for several months. You will find out how much rainfall your area gets month by month, and which winds bring rain.

OBSERVATIONS MADE AT WEATHER STATION X, U.S.A. 7:00 A.M.
RECORDING RAINFALL DAY BY DAY FOR A MONTH
(In Tenths of Inches)



DAYS OF THE MONTH

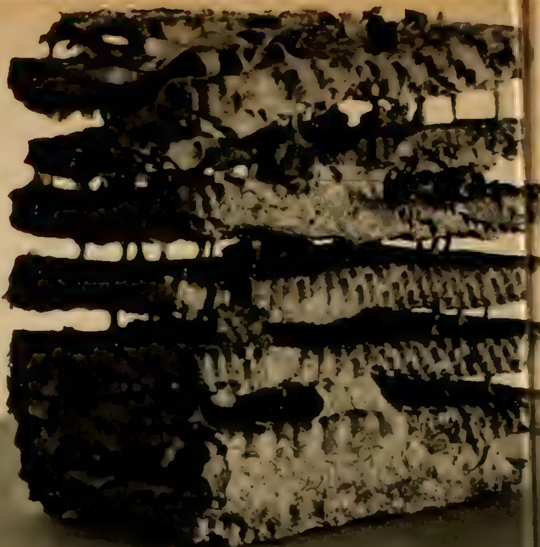
OBSERVATIONS MADE AT WEATHER STATION X, U.S.A. 7:00 A.M.
TOTAL RAINFALL FOR MONTH, ACCORDING TO WIND DIRECTION



WIND DIRECTION

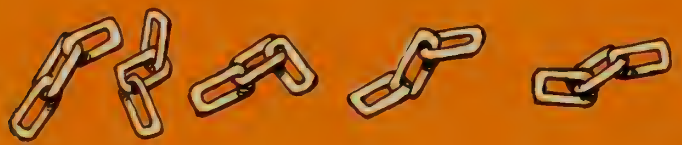
brain boosters

prepared by **DAVID WEBSTER**



CAN YOU DO IT?

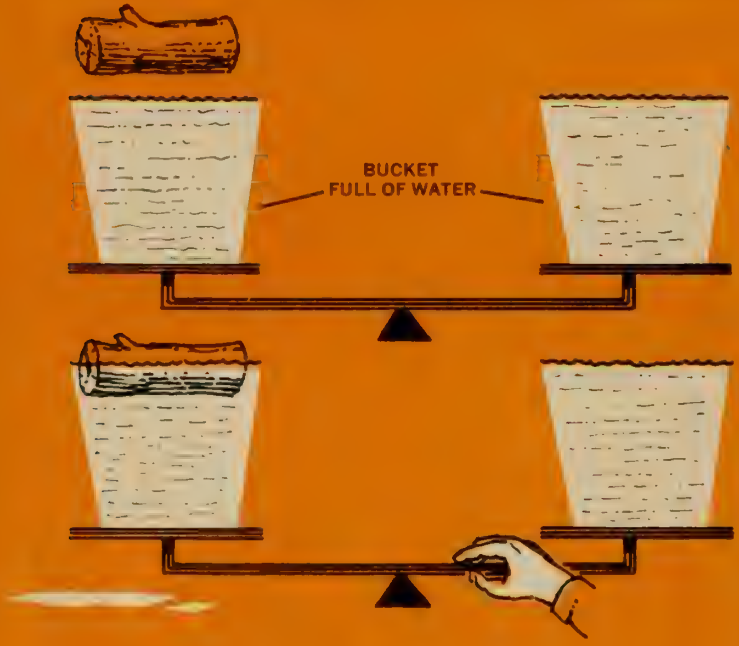
Suppose these 15 links are to be joined into one long chain. It costs 1 cent to cut a link and 2 cents to weld a link together. What would be the cheapest way to make a chain?



WHAT WILL HAPPEN IF?

What will happen when the log is put into the bucket of water? Will the bucket of water with the log be heavier, lighter, or the same?

submitted by Mrs. Marcella Baden, Niles, Michigan



FOR SCIENCE EXPERTS ONLY

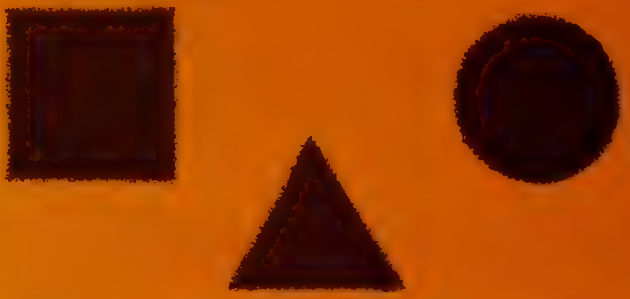
Can you explain this science contradiction? The sun is closest to the earth in June, but the warmest days are in July and August.

MYSTERY PHOTO ↑

Most paper wasp nests are round, but this one is square. Do you know why? Where did the wasps make it?

FUN WITH NUMBERS AND SHAPES

The drawings show shadows made by something held in different positions in front of a light. What shape could make all these shadows?



ANSWERS TO BRAIN-BOOSTERS IN THE LAST ISSUE

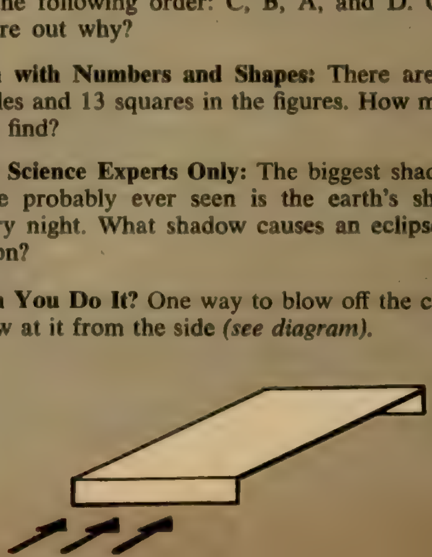
Mystery Photo: A picture of floor rafters in a new building. It is upside down.

What Will Happen If . . .? The tacks would drop off in the following order: C, B, A, and D. Can you figure out why?

Fun with Numbers and Shapes: There are 47 triangles and 13 squares in the figures. How many did you find?

For Science Experts Only: The biggest shadow you have probably ever seen is the earth's shadow—every night. What shadow causes an eclipse of the moon?

Can You Do It? One way to blow off the card is to blow at it from the side *(see diagram).*



Using This Issue . . .

(Continued from page 2T)

by Thor's chariot, and that thunderbolts (lightning) were his hammer. Greek and Roman gods (Zeus and Jupiter) were said to hurl thunderbolts when angry.

It is not unusual today to hear people discuss the false notion that a thunderstorm is *caused* by thunder *and lightning*.

- You might encourage your pupils to volunteer as many superstitions about thunderstorms as they can think of, then list them on the board. After they have read the thunderstorm article, work down the list on the board and see how many of the false notions they can dispel in the light of what is known about thunderstorms.
- *Lightning never strikes twice in the same place. Or does it?* The following is from a U.S. Department of Commerce bulletin (GPO: 1962 0-657647): "In Illinois a farmer's barn was set afire by lightning, killing all the livestock except two horses. A week later it struck his metal hayshed, destroying it and then a few days later it flicked along a fence and knocked the farmer unconscious. A few months later a lightning bolt followed him into a neighbor's barn and killed him—injuring nothing else."
- *What are the relationships between tornadoes, hurricanes, and unusually big thunderstorms?* A thunderstorm is a local, severe storm which is produced by a cumulonimbus cloud and is always accompanied by lightning, thunder, rain, and sometimes by hail.

A tornado is a violent local storm with whirling winds of tremendous speed. It is usually recognized as a rotating funnel-shaped cloud that extends toward the ground from the base of a thunderstorm.

A hurricane is a large rotating storm *(see radar picture of a hurricane on page 7)* that is accompanied by violent winds, heavy rains, and high waves and tides. Hurricanes originate in all tropical ocean areas except the South Atlantic, and usually move from low to higher latitudes with increasing speed, size, and intensity.

PAGE 8 The Winds

This WALL CHART illustrates the fact that air always flows from a region where the atmospheric pressure is high to a region where it is lower. This flow of air makes up the winds, global and local. It results from the tendency of adjacent parcels of air to equalize in density. (A given volume of air in a high pressure system contains more molecules than the same volume of air in a low pressure system.)

The winds described in the chart are "ideal" winds. The westerlies, for example, do not blow steadily at the earth's surface. We feel the effect best at altitudes where the airliners fly, where there are no mountains, valleys, plateaus, and other disrupting land features to interfere with the wind flow. Other variations in the westerlies are caused by warm, moist air moving up from the south, and by cold, dry air moving down from the north. Air from these two *source regions* of air masses meets in the path of the westerlies, contributing to the ever-changing winds in the westerlies belts, and making it our most active weather belt.

Your pupils may wonder where the "air masses" mentioned in this issue come from. The diagram on this page shows six source regions of air masses that influence weather patterns in the United States.

References

- *The Nature of Violent Storms,* by Louis J. Battan, Anchor Books, Doubleday and Co., Inc., New York, 1961, 95 cents.
- *Cloud Physics and Cloud Seeding,* by Louis J. Battan, Anchor Books, Doubleday and Co., Inc., New York, 1962, $1.25
- *Manual of Lecture Demonstrations, Laboratory Experiments and Observational Equipment for Teaching Elementary Meteorology in Schools and Colleges,* by Hans Neuberger and George Nicholas, Department of Meteorology, Pennsylvania State University, University Park, Pa., $2.
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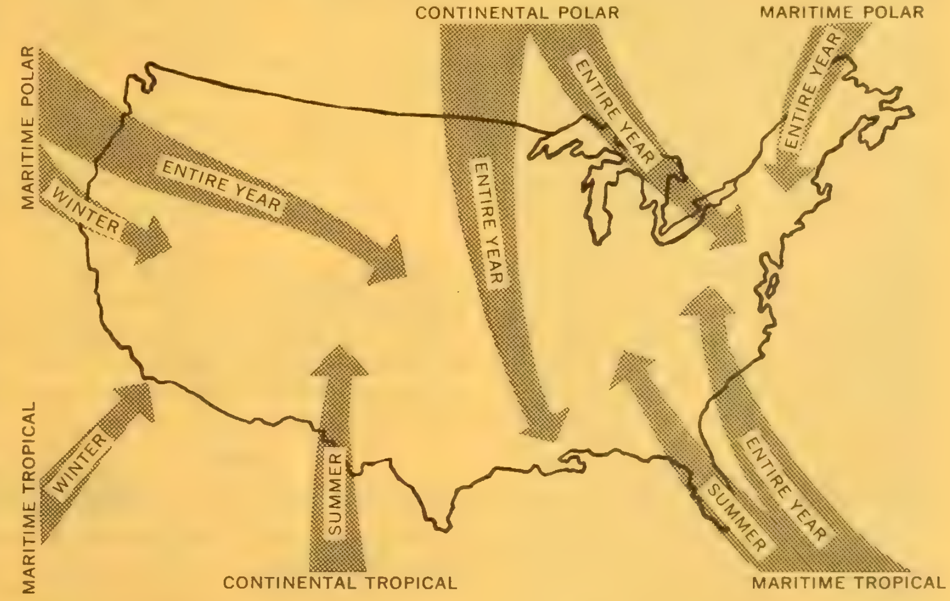
- *Book of Storms,* by Eric Sloane, Duell, Sloane and Pearce, New York, 1956, $3.50.
- *Our Atmosphere,* by Theo Loebsack, Anchor Books, Doubleday and Co., New York, 1961, 50 cents.
- *Weather Elements,* by Thomas A. Blair and Robert C. Fite, Prentice-Hall, Englewood Cliffs, N.J., 1957, $6.75.
- *The Weather Workbook,* by Fred W. Decker, Weather Workbook Co., Corvallis, Ore. 1962, $1.60.
- *Weatherwise,* a magazine published by the American Meteorological Society, Boston, Mass., $4 per year.
- *Planet Earth,* $5.75 for a set of posters, or $9.50 for the posters and package (which includes classroom experiments and teacher's pamphlets about the weather, climate, ice, geophysics, plus pamphlets for pupils. Write to Mr. Thomas Gikas, Space Science Board, Suite 716, 1145 19th St. N.W., Washington, D.C.
- Pamphlets available from the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C.: *Weather Bureau at Work* (No. C 30.2: W 37/7) 10 cents. *An Annotated Meteorological Bibliography for Secondary Schools,* 15 cents. *Climatology at Work,* 1960 (No. C 30.2: C 61/2) 65 cents.

SOURCE REGIONS OF AIR MASSES



Polar continental air masses are cold, dry air that sweeps down from Canada. Maritime air masses may be warm and moist (tropical in origin) or cold and moist (polar).

A New Look at the Weather
(Continued from page 1T)

Research rockets with new miniature instruments are now examining the atmosphere up to heights of 50 and 100 miles. Over the next few years a world-wide network of rocket sounding stations will be making routine daily observations.

Since 1957, improved weather detecting radars have greatly assisted meteorologists in detecting rain and snow over areas without observatories. "Weather search" radars can detect precipitation within a range of 250 miles from the antenna site.

Satellite Observations

The first meteorological satellite (TIROS) was launched April 1, 1960 by NASA. Since then 10 TIROS satellites have been placed in orbit with great success. Hundreds of thousands of televised photographs have added a new dimension to observations of large-scale cloud patterns.

TIROS III scored an historic first by locating a suspicious cloud area on Sept. 10, 1961. Televised photographs made over the Atlantic Ocean showed a circular cloud pattern which was confirmed the following day by ship reports. The next day weather reconnaisance hurricane-hunter aircraft reported that "Esther" had developed hurricane force winds.

Last month the first NASA-Weather Bureau operational satellite system (TOS) was put into polar orbit. The two satellites comprising the system are now providing continuous coverage of the earth's surface. Data is recorded on tape and transmitted to the Data Processing and Analysis Facilities at the National Environmental Satellite Center in Maryland, for automatic processing.

Information from TOS satellites is combined with data obtained from world-wide conventional observatories for use in daily weather bureau analysis and forecasting. The satellite photographs are relayed to field stations around the world.

The Role of Computers

The quantity of data now being collected is so extensive that meteorologists must depend on electronic computers to analyze the information.

Computers receive data about the wind speed and direction, temperature, and humidity at hundreds of points on the earth's surface and at each of nine levels of the atmosphere. More than 100,000 bits of information are used to obtain a picture of the atmosphere at a given moment.

Following instructions from scientists, the computers predict the changes in wind speed and direction, temperature, and humidity for more than 10,000 places, providing forecasts for 24, 48, and 72 hours in advance. To forecast a single day's air movements over the Northern Hemisphere, a computer must perform about 100 million operations. This is done in about three to four hours after the observations have been fed into the machine.

The last but most important link in the meteorological chain is to get data to forecasters in the field, whose job it is to warn farmers, mariners, fishermen, pilots, and you of an approaching storm, or issue the welcomed spring forecast, "Tomorrow, fair and warmer" ■

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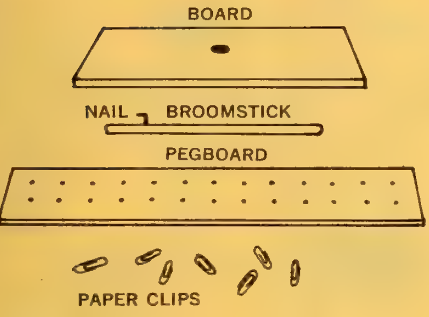
Turning Discovery into Thought

by Brenda Lansdown



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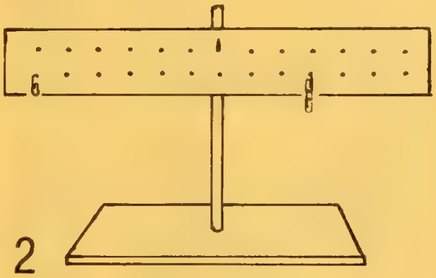

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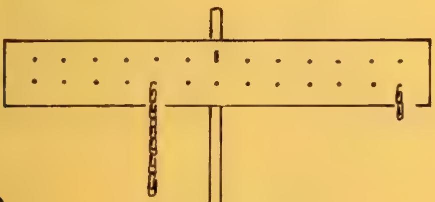

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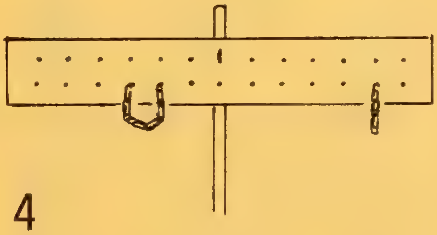


4

■ What has a 12-year old discovered when he takes materials such as those in Diagram 1 and sets them up as in Diagram 2?

Maybe he has discovered the law of levers. But then again, maybe he hasn't. Suppose that a few minutes later, this boy, Alfred, arranges his materials as in Diagram 3. We might then begin to confirm our hypothesis about the boy's virtuosity.

In the same class, Rose balanced her equipment as in Diagram 4. We might conclude that she is ingenious, but we still do not know what each child has learned. However, when the children gather to share their discoveries, we listen to the discussion. Alfred asserts: "I discovered that the farther from the pin, the fewer paper clips you need to balance." All the other children agree except Rose.

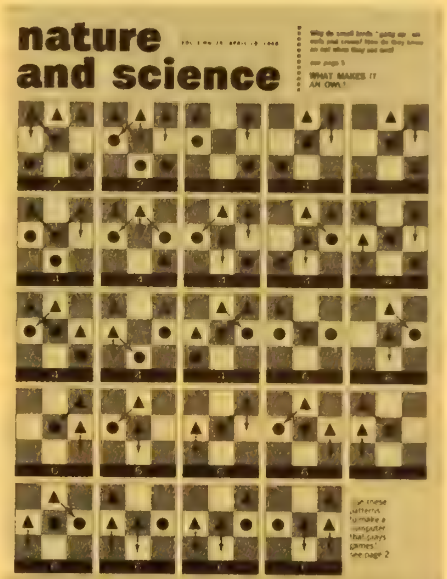
Alfred's discovery and his way of thinking about it is now clear to us. In what way is Alfred's discovery different from that of two six-year-olds playing on a see-saw when the heavier child moves nearer to the fulcrum so that the pair can pump up and down? Or when the heavier child moves out to the tip of the board and holds the lighter child suspended high in the air? From this much information we do not know for sure what the younger children have discovered except a kinesthetic joy of triumph on the part of one.

The fact that we do not know for sure what the teeter-totter tots have learned does not mean they have learned nothing. On the contrary, the sequence of actions shows that some learning has taken place. The children too may not realize what they have learned. Only their muscles know for sure!

But let's return to the discussion of balances by our 12-year-olds. After several children have made statements

(Continued on page 3T)

Brenda Lansdown is an Associate Professor of Education at Brooklyn College of The City University of New York. The classroom situation is based on a record made by George Z. Tokieda.



IN THIS ISSUE

(For classroom use of articles preceded by ●, see pages 2T and 3T.)

Can You Beat Tim?
Your pupils can make a simple computer with match boxes and find out how it "learns" to beat them at a checkers-like game.

● **What Makes It an Owl?**
A scientist tells how his students investigate the phenomenon of "mobbing," when small birds attack their enemies.

Man's Changing Views of the Moon
From imaginary drawings to the latest photos, this WALL CHART traces man's growing knowledge of the moon.

● **"I Have a Virus..."**
Part 1 tells how vaccines were developed to ward off virus diseases before viruses had been discovered.

● **How Far Can You Hear a Tick?**
Your pupils can use a clock and some coins to test their hearing and to discover how their two ears help them locate the direction of sounds.

● **Can a Flood Drown a Plant?**
Using six Coleus plants and some milk cartons, your pupils can test the effects of flood waters on plants.

IN THE NEXT ISSUE

A zoo scientist tells how to observe messages between animals . . . "I Have a Virus," Part 2: Is a virus alive? . . . A WALL CHART on animal "camouflage."

USING THIS ISSUE OF NATURE AND SCIENCE IN YOUR CLASSROOM

5 Owl Mobbing

It is interesting to observe the actions, structures, and processes of animals that enable them to survive. Mobbing behavior is one example. Although it is difficult or impossible to prove the mobbing "works," scientists assume that it has some survival value to the birds that do the mobbing.

Even if your class is unable to attempt testing the effects of different models of owls, it would be worthwhile to set up one model and observe the results. Be sure that the model is set up near some shrubs or beside a woods *(see article for more details)*. This is where an owl might naturally be found and where smaller birds live. A model owl set up outside your classroom window will probably yield no results unless there are many shrubs and trees nearby.

The months of May, June, and July, when many birds are nesting, are best for seeing and testing mobbing behavior. Many birds mob crows, as well as owls. You might suggest pupils investigate mobbing with models of crows as well as of owls.

References

Three useful sources of information on bird behavior are *Animal Behavior*, by Niko Tinbergen, LIFE Nature Library, Time Inc., New York, 1965, $3.95 (includes color photos of a blue jay mobbing an owl); *Animal Behavior*, by John Paul Scott, $1.45 (paper), and *A Guide to Bird Watching*, by Joseph Hickey, $1.25 (paper)—both from The Natural History Library, Anchor Books, Doubleday & Company, Inc., Garden City, N.Y., 1963.

10 Viruses

Your pupils have probably been vaccinated at one time or another, and they may think of a virus as some kind of "germ." But they may not know that most vaccines are used to ward off diseases that are caused by viruses.

Part 1 of this two-part article tells how vaccines against smallpox and rabies were developed even before viruses had been "discovered." Part 2 will describe viruses in some detail and discuss the question of whether they are "alive."

Topics for Class Discussion

- *How did Martinius Beijerinck "discover" viruses when he couldn't even see them?* To find out what caused the tobacco disease, he followed a method devised about 10 years earlier by a German doctor, Robert Koch. Koch reasoned that: 1) If a particular organism was always found associated with a disease, and 2) If the organism could always be isolated in a pure culture from the diseased tissues, and 3) If the pure culture, when inoculated back into the healthy tissue, caused the disease, — then, and only then, could scientists say with certainty that the organism caused the disease.

Following these results, Beijerinck proved that something in the clear fluid that passed through his filters caused the tobacco disease. Because bacteria of many kinds could be seen through the microscopes then available, and because he could see nothing in the fluid, Beijerinck concluded that the cause of the tobacco disease was some hitherto undiscovered kind of "poison." (The word "virus" was then just another word for poison.)

Beijerinck might have been wrong, because we have since discovered some kinds of bacteria that are smaller than some viruses, so the clear fluid that passed through Beijerinck's filters might have contained such bacteria. But Beijerinck *had* made a discovery, and part 2 of this article will tell how scientists confirmed it.

- *What are bacteria?* Bacteria are tiny living things that are widely distributed in soil and water and on plants and animals. Bacteria are now classified as "protists" by many scientists *(see "When is a Plant Not a Plant?"*, N&S, *Oct. 4, 1965)*. There are a variety of forms, including the one-celled forms known popularly as "germs." Bacteria have many useful functions, such as causing the decay of dead plants and animals, yet some are the causes of certain diseases in animals and plants.

14 Flooded Plants

Flood waters have a variety of effects on plants, such as reducing the amount of sunlight and contaminating the plants with chemicals. But the most serious effect is stopping the intake of air by the roots. In this regard the roots are more sensitive than the stems and leaves. Your pupils can probably observe this by comparing the three plants that are flooded the most *(the three on the right side of the diagram on page 15)*.

Even if your class does not try the investigation, have them discuss the "box" on page 15 about controls in experiments. You might review past botany workshops in *N&S* to identify and discuss the controls in different investigations.

13 Hear a Tick

We take it for granted that other people hear as well as we do, but this is not always true. It has sometimes been found that there is nothing wrong with a "slow learner" except that he can't hear well.

Topics for Class Discussion

- *The mechanics of hearing* can be explained and discussed with the aid of the diagram on page 3T.
- *You might discuss with your pupils the question: If a tree falls in a forest and there is no one around to hear it, is there any sound?* The answer depends on how you define the word "sound." The crashing tree produces vibrations in the air called *sound waves*. But is this "sound"?

(Continued on page 3T)

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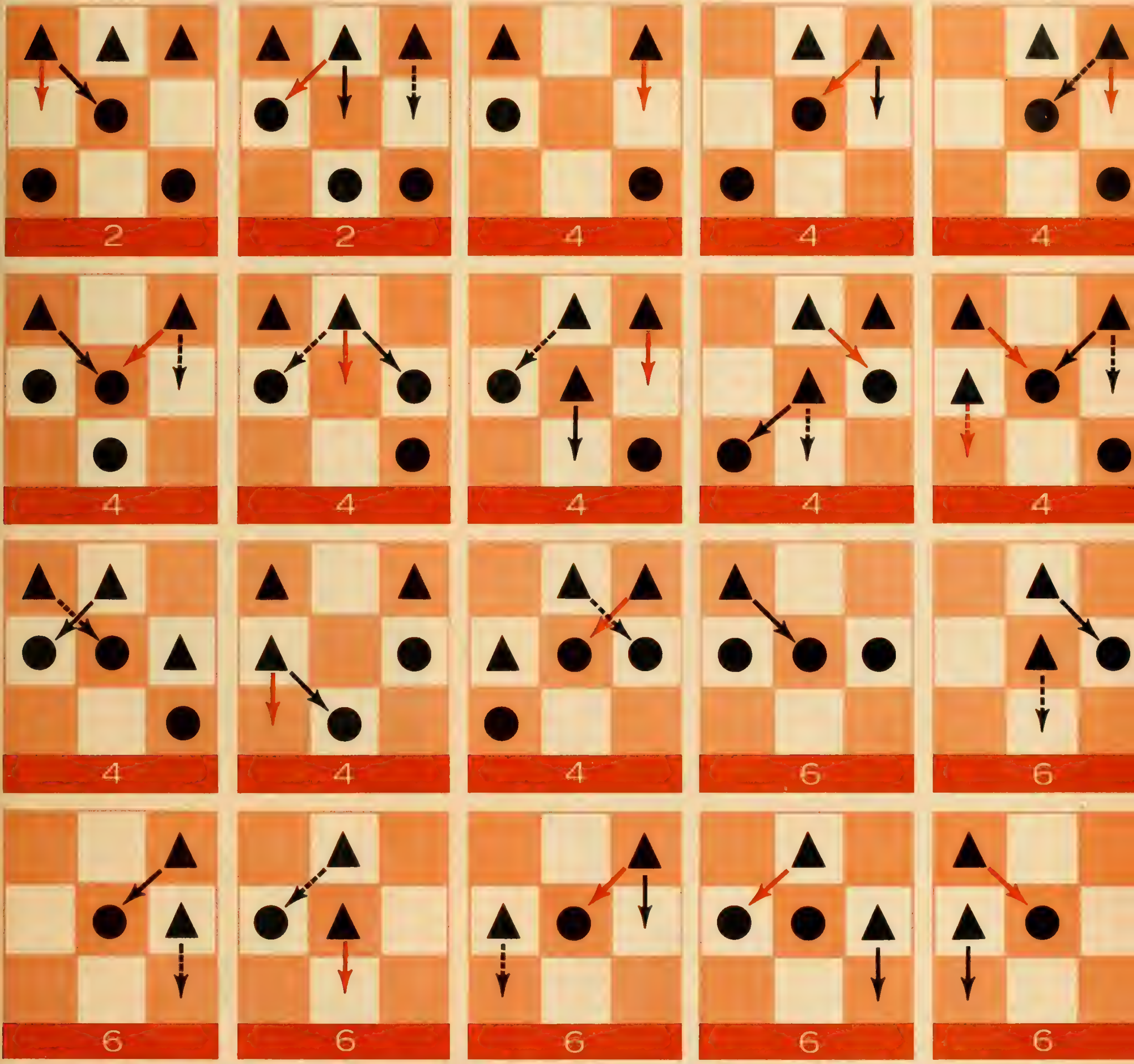
Why do small birds "gang up" on owls and crows? How do they know an owl when they see one?

see page 5

WHAT MAKES IT AN OWL?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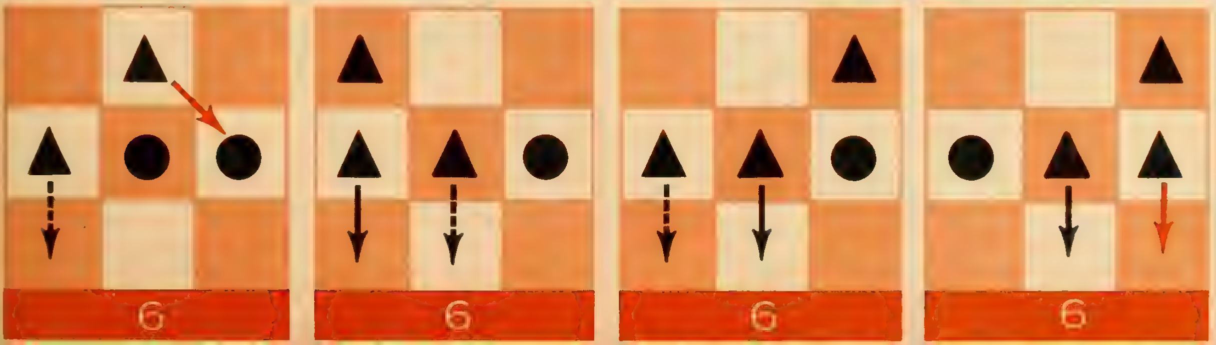

Use these patterns to make a computer that plays games!
see page 2

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10 "I Have a Virus...", *by Helena Curtis*
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SCIENCE WORKSHOP

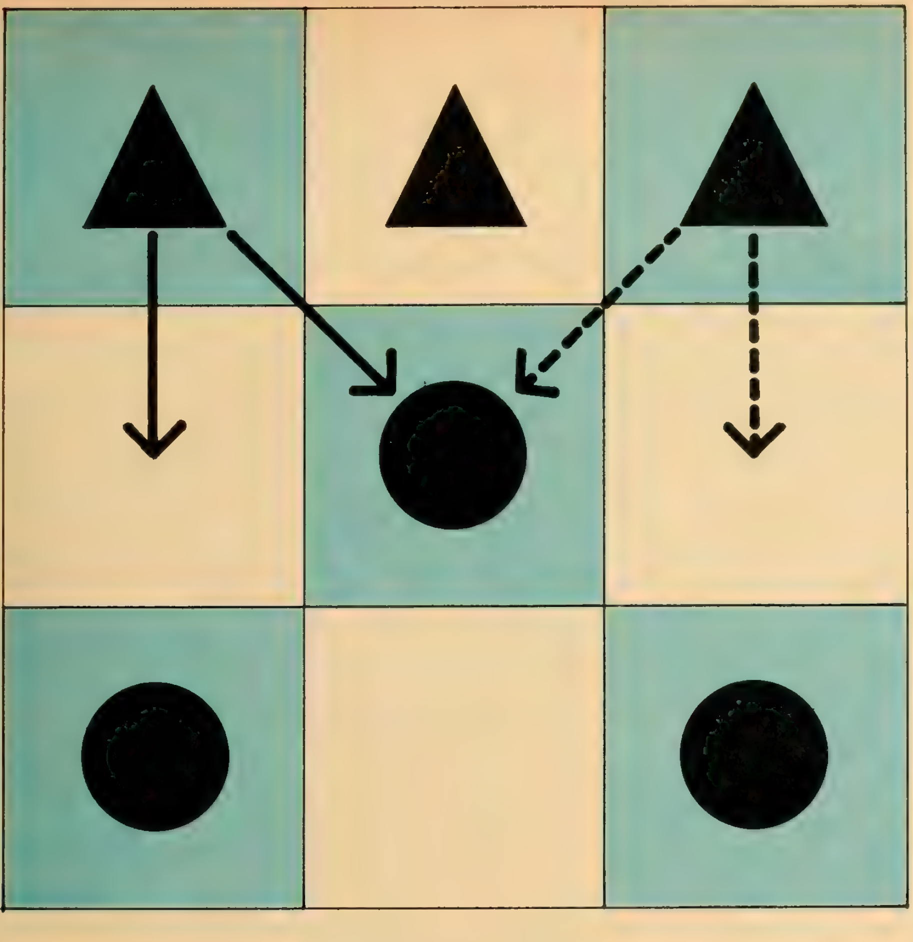
CAN YOU BEAT TIM

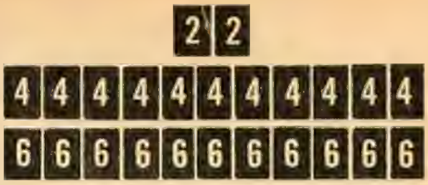
by
Roy A. Gallant

A match-box machine that learns as it plays

WHAT TO DO WITH THE COVER

Cut out the patterns printed on the cover of this issue and paste each one on the top of a match box. Each pattern shows moves your idiot machine can make in the game.





Arrange the match boxes with labels as shown here.

How the game is played: Say that you make the first move by advancing your middle man one space. TIM can move one of his end men forward one space, or he can move one on a slant and capture your man. If he moved a man forward one space you could win the game on the next move by capturing TIM's other cornerman, and thus reaching TIM's king's row.

■ Have you ever heard of a machine that can be taught to play a game something like checkers? Not only that, but the machine becomes a better player as you and it play more games together. It "learns" to play a better game because you reward it when it wins or you punish it when it loses. You can build such a machine easily and teach it to play a game—but you may not be very happy about it. Although the machine is an idiot, it will learn to play the game so well that eventually it will beat you every time.

Martin Gardner invented the game described in this article, and wrote about it in the March 1962 issue of *Scientific American* magazine. He and the editors of *Scientific American* have given us permission to describe the game in *Nature and Science*.

We have renamed the machine TIM, for "Teachable Idiot Machine." The game you and TIM can play is quite simple. As the diagram shows, you will need a card with nine squares. You have three tokens (pennies, say) and TIM has three tokens (nickels). Or you can use checkers or chess pawns. You win the game in one of three ways: 1) by moving a man to TIM's king row; 2) by blocking TIM so that he can't make a move; or 3) by taking all of TIM's men.

How To Play: The moves are simple. A man can move only one space at a time. If he is moving into an empty space, he can move forward only, as the diagram shows. The only time you can move on a slant is when you are taking one of TIM's men, or when he is taking one of yours. No man can move backwards or sideways. Before you build TIM, you might make the nine-square board and practice a few games until you get the hang of it. (TIM already knows how to play the game, but he doesn't play it very well—not yet, anyway.)

How To Make the Machine

You will need 24 small match boxes and a bag of small "m&m" candies (the color doesn't rub off on your fingers), or small colored beads. Cut out the 24 patterns on page 1, paste each one onto a match box, then arrange the match boxes in three rows—the two boxes with 2 on them in the top row, the 11 boxes with 4 on them in the middle row, and the 11 boxes with 6 on them in the bottom row.

Next, put m&m's in the boxes. Notice that each box has arrows on it. If a box has one brown arrow and two black arrows on it, put one brown candy and two red ones in the box (there are no black m&m's). Put candies in each box exactly as the arrows show.

By now you have probably figured out what the patterns on the boxes mean. Each pattern represents the game board. The triangles are TIM's men and the circles are your men. Since you always make the first move of

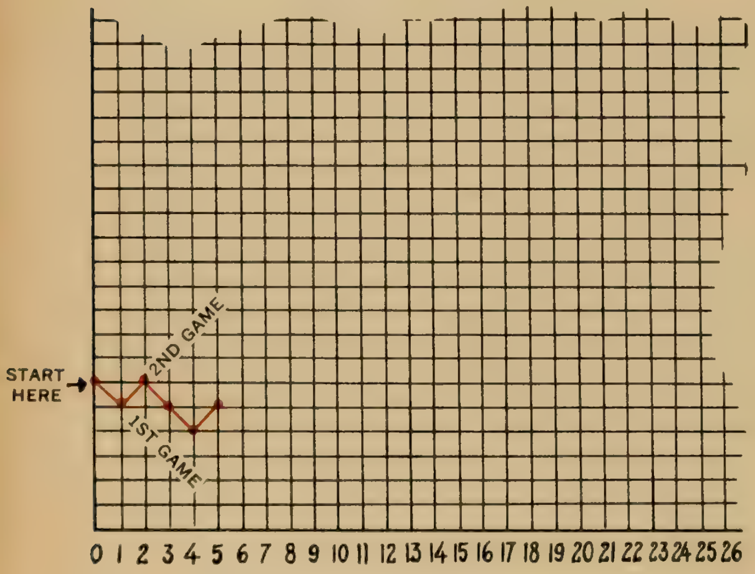
(Continued on the next page)

every game, TIM makes the second move. And since there are only two possible second moves, there are only two boxes with a 2 on them. You then make the third move, TIM makes the fourth (one of the boxes with a 4 on it), and so on.

How To Play Against TIM

Before helping TIM to become a better player by rewarding or punishing the machine, play two or three games for practice. Remember, you always make the first move. There are two first moves you can make. You can move your middle man forward one space, or you can move your left man forward one space. (Moving the right man forward one space would be just the same as moving the left man, so TIM is designed to handle only one of these moves—your left-man-forward move.)

Say that you move your middle man forward one space *(see page 3)*. It is now TIM's move. Pick up the match box that shows your middle man in the center square. Shake the box, close your eyes, take out a candy, close the box, and put it back with the candy on top. If the candy is red, TIM takes your man, as the black arrow shows. If the candy is brown, TIM moves forward one space, as the brown arrow shows. Now it is your move again (move number 3 in the game). After you have moved, it is TIM's turn—move number 4. Find the match box (marked 4) that has the right pattern on it, shake it, close your eyes, and pick a candy as before. If TIM did not win the game with move number 4, you move again, and so on. When the game is over, put the candies back in the boxes. You will then be ready to start a new game.



Make a graph like this one to keep track of TIM's wins and losses. On the graph shown here, TIM lost the first game, won the second game, lost the third and fourth games, and won the fifth game. What shape will the curve be when TIM learns to play a winning game each time?

After a few practice games, try playing a set of 50 games with TIM—this time punishing TIM whenever he loses a game. Punishing TIM will teach him to play a perfect game every time.

How To Punish TIM

Here is how to punish TIM. Suppose that TIM loses the game when he makes move number 4. If his *losing* move was made with the brown candy, *do not put the brown candy back in the box*. Play the next game without it. You may even eat the brown m&m. You have punished TIM and, if there was only one brown candy in the box, you have prevented him from making the same losing move again. In other words, TIM has "learned" to make a move that will not be a wrong move.

Play 50 games with TIM, each time punishing the machine whenever it loses a game; remember, take away only the "wrong-move" candy that made TIM lose the game. Keep a record of the games you play by entering TIM's wins and losses on a graph like the one on this page. We have plotted 5 games—3 losses and two wins. You will probably get a different line pattern, or *curve*. What shape does the curve have after the 10th game? After the 20th? After the 35th?

How To Reward TIM

Do you think that TIM would learn to play only perfect games more quickly if you rewarded his winning moves instead of punishing his losing moves? Try it. Play another set of 50 games and reward TIM for each game he wins. Do this *by putting into TIM's last-play box an additional candy which is the same color as the candy that made TIM win the game*. What do you think would happen if you rewarded *and* punished TIM during a set of several games? For example, if you took away the colored candy that caused him to lose the game, and at the same time gave him an additional winning-color candy? Would this make TIM "learn" any faster? ■

INVESTIGATION

FOR MATH EXPERTS ONLY

What do you think would happen if you made the game board larger by making it four or five squares wide (not deeper) instead of three squares wide? Who would win the new game, you or TIM? To find out, you would have to make a new board and design additional match-box patterns for the greater number of possible moves TIM could make.

Small birds gang up on owls and attack the larger birds. Scientists are trying to find out, from the birds' point of view...

WHAT MAKES IT AN OWL?

by George W. Barlow

The great horned owl, found throughout North America, is often mobbed by crows and other birds.

■ Small birds sometimes do a curious thing. They join together and attack their much larger enemies, even when their enemies are not bothering them.

Scientists who study birds call this *mobbing behavior*. "Mobbing" means that the attack is done by a group of birds. But the same attack may be made by a single bird. Small song birds seem to do the most mobbing, but larger birds also do it. So do other animals. Baboons, for instance, have been seen pestering lions, and even people, in a "mobbing" way.

Usually the animal that is being mobbed is in some way an enemy of the birds. Or it may be an animal that *could* be an enemy, such as a man or a dog. Mockingbirds, in groups or alone, sometimes mob cats. Birds also have been known to mob snakes.

The best known kind of mobbing is the ganging up of small birds on larger ones. Small birds sometimes attack blue jays by "scolding" and pecking them. (The blue jays sometimes steal eggs from the small birds' nests.) Small birds also attack the European cuckoo. This bird lays its egg in the nest of another bird. As soon as the egg hatches the baby cuckoo throws out the babies or eggs belonging to the nest. The rightful owner of the nest, for good reason, attacks cuckoos.

By far the most frequent victims of mobbing are owls. Most of what I will have to say from now on is about birds mobbing owls.

Different kinds of birds react to owls in different ways. Some species ignore owls altogether. Others mob only during the breeding season; still others mob all year round. Also, there are different ways of mobbing. Some species hold their wings out as if to frighten the owl. Others chatter but stay in hiding. Still others attack the owl, pecking and clawing it.

Mobbing by most small birds follows a general pattern like this: At first the small birds approach the owl, but they keep hidden in the underbrush. Then some of the birds fly out of the brush to peck or claw the owl, while others merely fly towards it.

During the mobbing, most birds make a noise that sounds as if they were "scolding." This is known as the *mobbing call*. It is much the same from one species to another and is probably understood among different species of small birds—a sort of "international" language. Usually the call is low and sharp, and is repeated over and over again: *tuck, tuck, tuck*. The call seems to mean "enemy in sight, rally around."

Crow hunters make use of this knowledge by playing records of the crows' mobbing call. The eager crows are lured to the hunters' hiding place, expecting to find other crows mobbing an owl. Instead, they find the hunters.

Does Mobbing Really Work?

Mobbing raises some interesting questions; for example, does it "work"? Does it keep enemy animals from eating the small birds? Does it stop cuckoos from laying eggs in other birds' nests? These are hard questions to answer, because they require information that is not easy to gather.

(Continued on the next page)

Dr. George W. Barlow is an Associate Professor of Zoology at the University of Illinois, Champaign, Illinois.

Other questions are easier. How do the birds choose a victim to mob? One way to begin to answer this question is to compare wild birds with birds that have been *hand-raised*, or raised in captivity, and have never had the chance to meet any of their natural enemies.

The wild birds mob almost any possible *predator*, which is any animal that would eat the birds. Hand-raised birds, such as song sparrows, will mob only certain objects, although they may act afraid of almost anything that "is strange to them." Owls seem to have a special ability to cause small hand-raised birds to mob.

Studies like these suggest that song birds somehow are able to recognize an owl even though they have never seen one. This might mean that the song bird is born with the ability to recognize an owl. If this is so, the bird might need to see only part of the owl in order to recognize it—say, the outline of the owl's body, or the shape of its head, or its saucer-like eyes.

To find answers to this question, scientists have put models of owls out in the forest and observed how birds have reacted to the models.

How do birds recognize an owl? This is a question I have asked my students many times. To answer it, several of them made models of owls. Then they put the models out in the woods to find out how small birds would react to the models.

By measuring how the birds reacted to different models, the students came up with some answers. Some features of the owl—for instance a pair of big round eyes—are more important than, say, the owl's beak.

Model of a Whole Owl

The first model the students used was a faithful copy of an owl. Some used a mounted owl. Others made a model of papier-mâché (bits of paper mixed with paste, put on a form and allowed to dry), and painted it to look like a real owl. Most of them cut an owl out of styrofoam and then painted it.

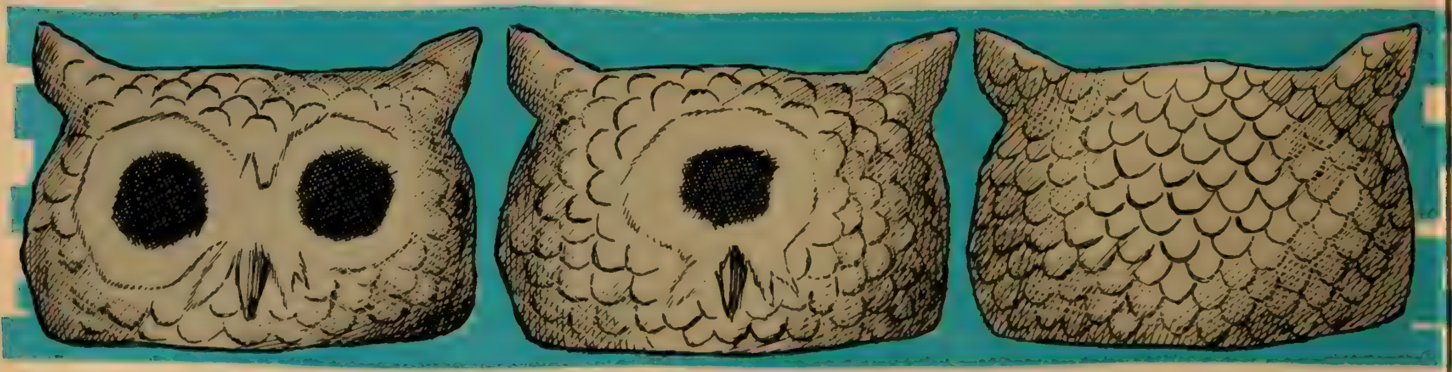
The first problem for the students was how to present the owl to the birds. The best way, it turned out, was to put the model on the end of a pole about 10 feet high. They also found that the best place to put the owl model was at the edge of a forest. Usually they chose a place where the model would be out in the open, but where it seemed to sit on a branch near some bushes. Then the students hid and waited to see what would happen. They discovered that the best time for this experiment is in the morning. Later in the day small birds are not nearly so active.

Now came the hard problem. How could the students

NYC
HIGHWAYS

BUT IS IT AN OWL?

If the pigeons that roost on this bridge in New York City recognized this as an owl, they showed no signs of it. When the plastic model was put up to scare them away, the pigeons neither fled nor mobbed it—they simply didn't pay any attention to it.



Here are some head and body shapes of owls to help you make some models. You might try a one-eye and a no-eye head, in addition to a two-eye head. You could paint all three brown and make the eyes and beak black. You could make still others and paint them red or some other color.

measure what the small birds do when they see a fake owl? At first so many things happened, and so rapidly, that the students were confused. They had to write down what the small birds did—how the birds reacted to different models, and how they reacted at different times of the year.

First, they counted the number of birds of each species doing the mobbing. The number of birds mobbing a model during, say, 30 minutes, might be one titmouse, two thrashers, five warblers, and one mockingbird. This told them how many different kinds of birds took part in the mobbing (four). It also told them the total number of birds (nine) mobbing during a certain period of time.

They also counted the number of mobbing calls per minute. But this was hard to do when they were counting the calls of more than one species. What they did was listen to only one species, a bird such as a thrasher that has a call easy to pick out. They found that the number of calls during each minute changed a lot over 30 minutes.

Some of the students counted how many attacks a certain species made on a model. One student was interested in how "daring" the birds were. He tried to estimate how closely each bird of a certain species went to the owl model.

One group of students worked very hard. They went to the same place every day and put out the same complete owl model. They were unhappy to find that each day there was less and less mobbing. It was as though the birds got used to the owl and learned to ignore it. But when the students moved the model of the owl from place to place in the forest, the birds mobbed it more.

The first time the mobbing experiment was done was in the spring, when the birds were breeding. The students always found birds that would mob the owl model. The next year some students put up owl models during the winter. Even though birds were around, the birds didn't mob the owl model very much. Birds seem to do much more mobbing during the breeding season than during the winter. Some birds seem to lose most of their interest in mobbing as soon as their young have grown up.

Models of Odd Owls

Some of the students tried to answer an even harder question: How do birds recognize an owl? You may think that they recognize an owl the same way you do. To find out, the students made different models to try on the birds.

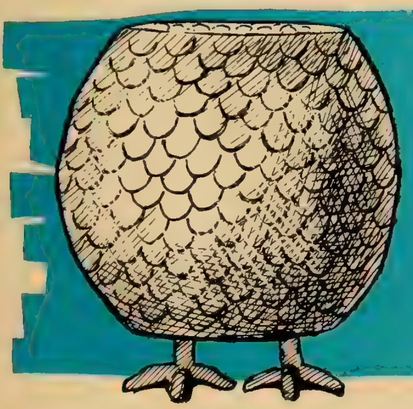
Their models differed in important ways. Different owl shapes were used. One owl had no head. Another owl was tall and thin, and so on.

They felt that most people recognized an owl from the shape of its face. Do birds recognize an owl the same way? The students changed the face in many ways. They quickly found that the eyes are important. They had great fun making owls that had no eyes, two eyes, four eyes, eyes on the back of the head. They even made an owl with one big eye in the middle of its face.

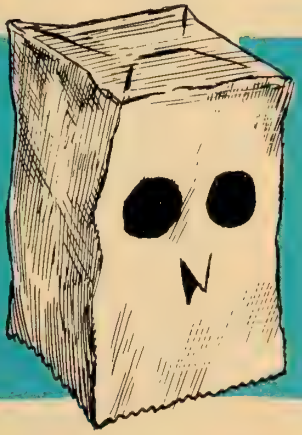
Other students thought that the size of the owl might be important. They made owls from the size of sparrows to the size of sheep. The owl models the birds mobbed most were about the same size as real owls.

Some students painted their models gay shades of red, soft green, brown, and even sky blue. They also changed the markings on the body. They stood some owls on their heads to find out what the birds would do. Sometimes they presented two owls at one time—say a brown owl and a green one—facing each other at the ends of a six-foot pole. By observing which of the models the birds attacked, the students could find out whether color seemed to make a difference to the birds in recognizing an owl.

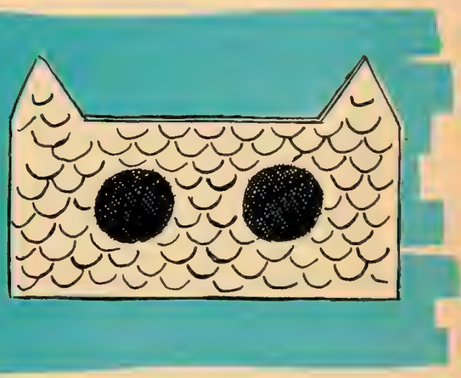
This spring maybe you would like to make some owl models and try them out on small birds near where you live. The illustrations on this page show some owl models that you can make. One question to answer: How do small birds recognize an owl? ■



Try making an owl body without a head.



Make a paper-bag owl with eye and beak holes cut out.



Cut a cardboard strip with dark eyes and ears.

nature and science | WALL CHART | *April 18, 1966*

man's changing views of... THE MOON

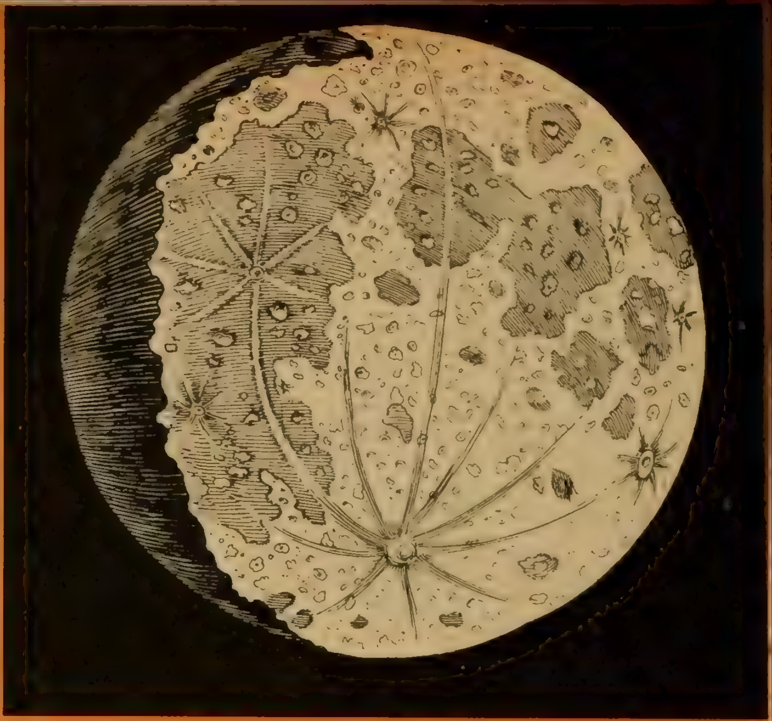
by Roy A. Gallant

■ Through the ages man's ideas about the moon have changed in many ways, and they are still changing today. Thousands of years ago the Egyptians, Greeks, and Chinese, among other peoples, looked on the moon as a god. Certain African tribes thought that the moon actually changed its shape from night to night. They believed that the moon offended the sun and that the sun punished it with its piercing rays until the shrunken moon asked for mercy. It then gradually regained its full, round shape.

As long ago as 2,000 years, Greek scientists argued that the moon was a rugged, rocky world with mountains and valleys. In the year 1609, the Italian astronomer Galileo studied the moon through one of the first telescopes. Many astronomers in the next three centuries looked on the moon as a smaller version of the earth. In the 1800s, this led to talk of voyages to the moon and reports of "scientific discoveries" that there were forests, animals, and vast cities on the moon.

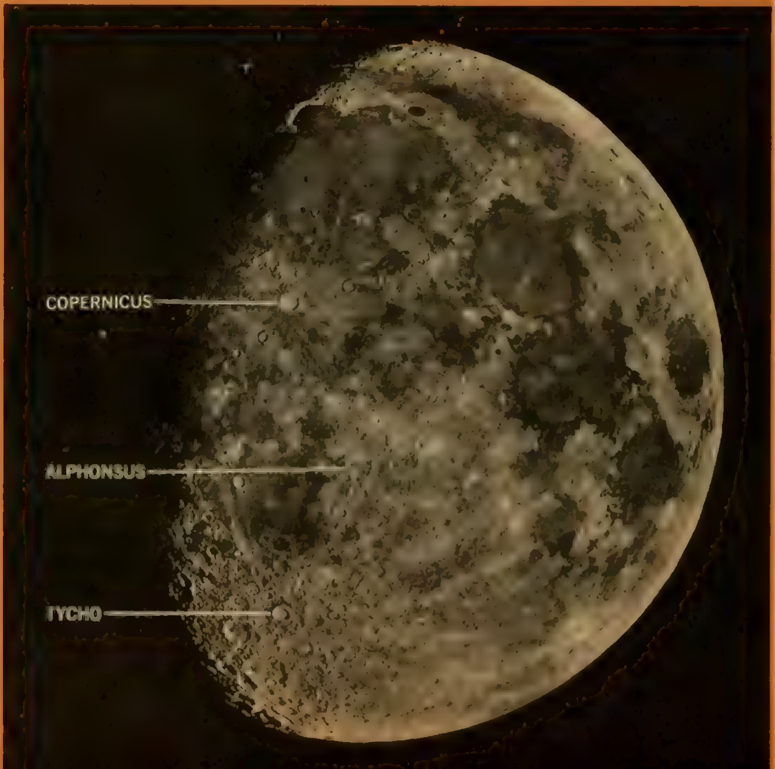
Today we know that the moon is an airless world only one-fourth the size of the earth. The daytime temperature of its surface is more than 200°F; its night-time temperature is about -250°F. If any living things exist there, they must be very simple forms of plant life.

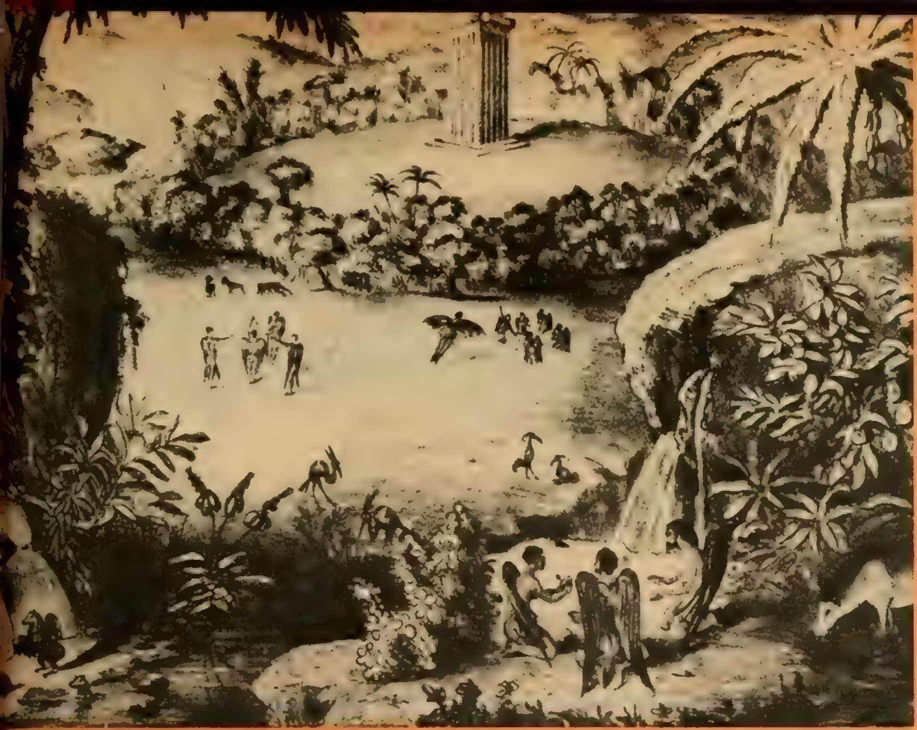
Photographs made through telescopes have given us detailed views of the side of the moon that faces the earth. And photos from Ranger IX and Luna 9 have given us close-up views of the moon's surface. By 1970, men may be landed on the moon. What they find there will undoubtedly change our ideas about the moon even further ■



This drawing of the moon was made by Galileo (about 1609) as he studied our satellite through one of the first telescopes. Unlike some astronomers of the time, Galileo felt that the moon's "seas" were not watery seas, but vast plains of dry rock.

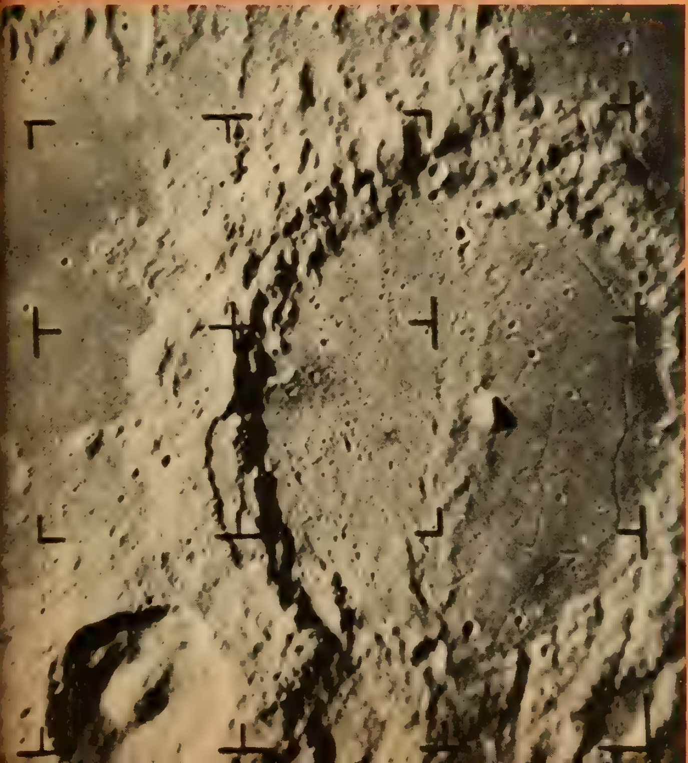
This Lick Observatory photograph, made with the 100-inch telescope at Mt. Hamilton, California, shows thousands of features of the moon surface. The dark areas are probably vast plains of dark rock. About 30,000 craters are visible through a telescope, some of them as wide as 50 to 150 miles from rim to rim. The large craters Tycho (near bottom of photo) and Copernicus (near top) have powder-like rays extending from them. No one knows what the rays are.

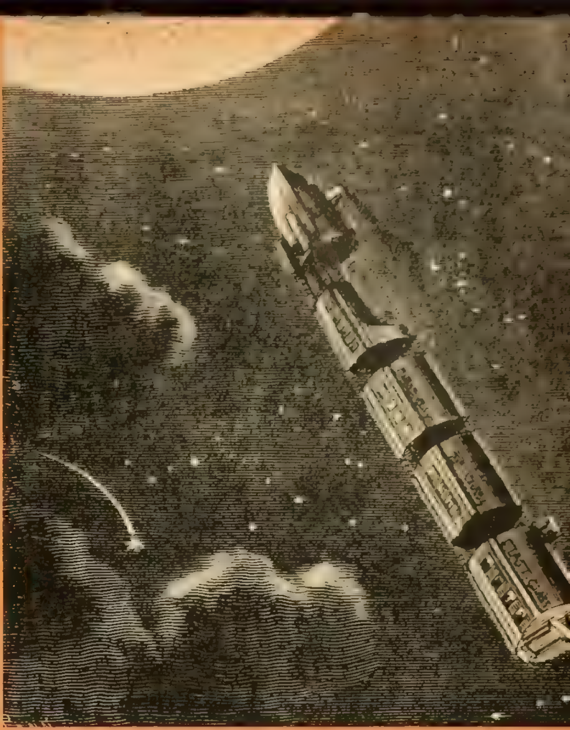




e 1800s there was a wide-spread belief that the moon was inhabited by people much
ourselves. This artist's view shows a lunar city with angel-like people living peace-
among wild animals. A lunar "temple" is seen in the background. Guided by fancy
r than fact, an 1835 edition of the New York *Sun* printed a long story about "life
e moon."

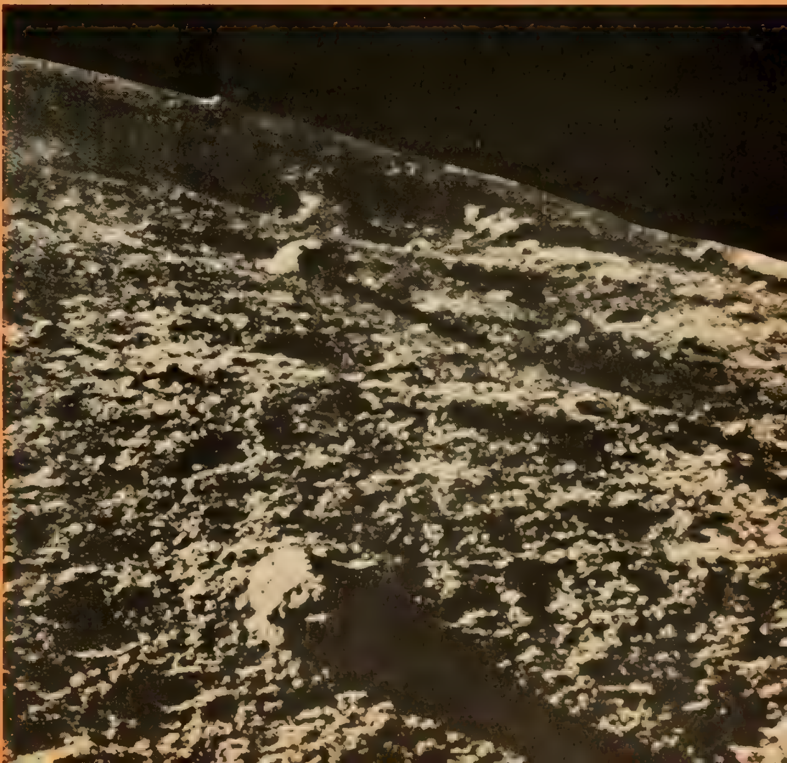
s photograph of the moon was made by the space probe
nger IX on March 24, 1965, from a height of 258 miles above
moon's surface. The area shown is about 120 miles by 110
les. The large crater is Alphonsus (*see left photo for its loca-*
n). The Ranger photo shows a pattern of ridges and "rills"
acks in the surface), and many small craters within Alphonsus.





More than a century ago, many writers were fascinated by the idea of space flight and tried to work out the engineering problems of sending a rocket to the moon. Shown here is a moon train invented by the French writer Jules Verne. It was intended to be shot from a cannon. How many things can you find wrong with this picture? What about the shooting star? The smoke trail? Clouds?

Early in 1966 the Soviet lunar probe Luna 9 landed on the moon and photographed its surface. For many years scientists have wondered if the moon's surface may be coated with a deep layer of dust, possibly so deep that a space craft might be smothered. The Luna 9 photograph shown here indicates that the surface where the craft landed is quite solid and rough, with many rock-like formations scattered about. No traces of deep, soft dust are visible. The rock casting the long shadow is about six inches across and about two yards from the camera.



PART 1

"I HAVE A VIRUS..."

by Helena Curtis

Long before scientists could see these mysterious particles of matter, they had found ways to "tame" viruses and protect us against many of the diseases caused by them.

■ You can probably remember lots of times when your mother called the doctor to tell him you were feeling sick and a little feverish, and he said not to worry, that you just had a virus. And you got to stay home for a few days and watch television and drink ginger ale, and very soon you were well again. Perhaps during those few days you wondered just what a virus is. Lots of people, including famous scientists, have asked this question, too, and the answer is still not entirely clear.

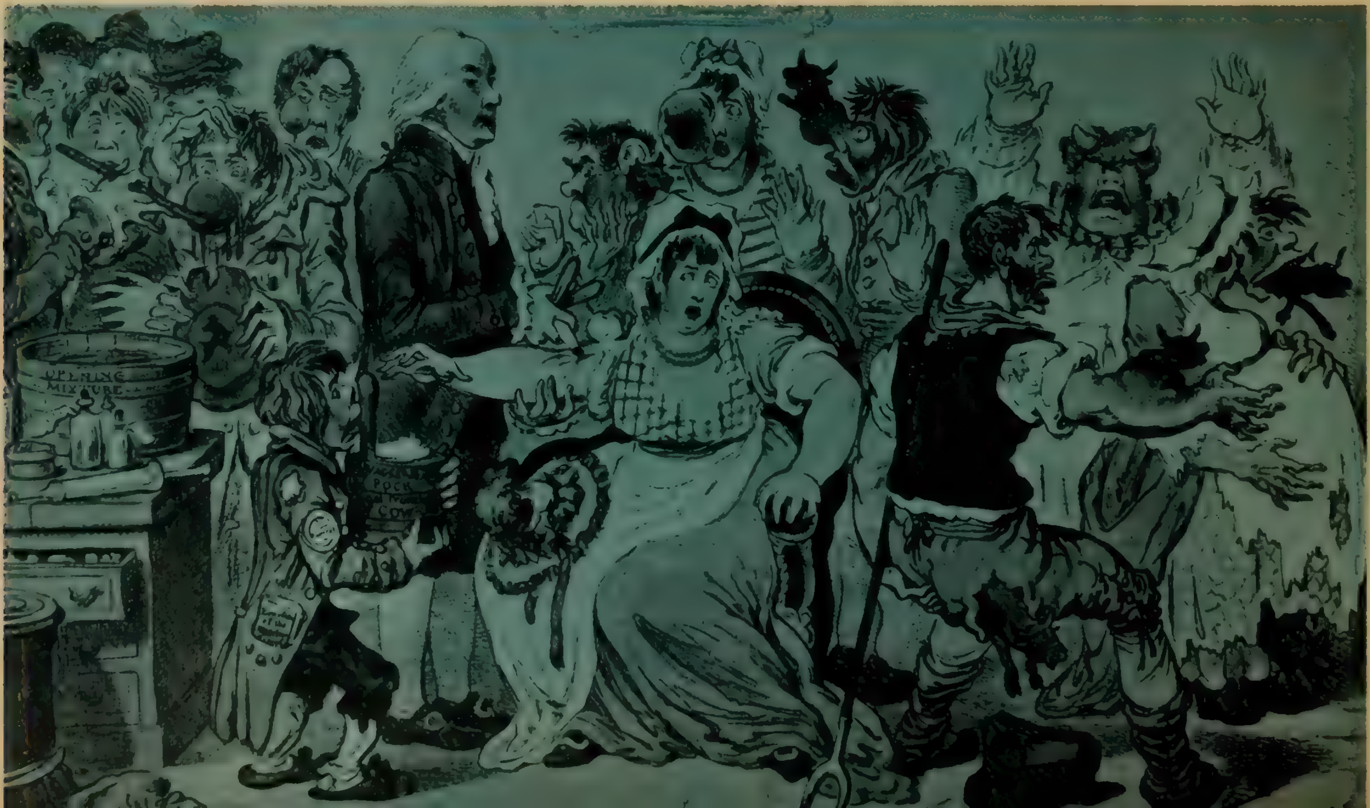
Viruses were first discovered in 1898 by a Dutch scientist, Martinus Beijerinck. Dr. Beijerinck was studying a disease that damaged the leaves of tobacco plants. This disease was convenient to study in the laboratory because it is not dangerous to work with. Also it can be transmitted easily from a sick plant to a healthy one by simply scratching the broad green leaf of the healthy plant and rubbing a little fluid from a sick leaf on it.

An "Invisible Poison"

By 1898, scientists had proved that many *contagious* diseases—diseases that spread from one living thing to another—are caused by germs, or *bacteria*, which could be seen through a microscope. Dr. Beijerinck was looking for bacteria that might be the cause of the contagious tobacco disease.

He took some of the fluid from a diseased leaf and strained it through a filter, or sieve, with holes so small that it could catch tiny bacteria. But when he examined the pulp that was left in the filter, he found no bacteria. When he spread the pulp on a healthy tobacco leaf no sign

The idea of injecting cowpox serum into people to ward off smallpox was not accepted by everyone. In 1802 the Anti-Vaccination Society of England published this cartoon suggesting that cowpox injections might have strange results.



of disease appeared.What had happened to the "germs"?

Although Dr. Beijerinck could see nothing in the clear fluid that had passed through the filter, he decided to scratch this onto a leaf also. The typical signs of the tobacco disease soon appeared! Something in the clear fluid caused the disease. Beijerinck called this something a "filterable virus" (a poison that passes through filters).

He noticed that this clear fluid had a remarkable ability: it could *reproduce,* or make more of itself. If he spread just a tiny drop on a leaf, he could extract many more equally poisonous drops from that leaf once the disease appeared. Eventually, enough of the fluid could be produced to infect thousands of leaves.

Nothing at all could be seen in the fluid, even with the most powerful microscopes then made. Yet something in the fluid could reproduce, which meant to Beijerinck that it was alive. In wonder and excitement, he wrote, "In its primitive form life is like a fire, like a flame borne by the living substance." Since his time, the study of viruses has not been just a study of disease, but also a study of what we mean when we say that something is "alive."

The First Vaccination

Although Beijerinck was the first to "discover" a virus, two of the most dangerous diseases caused by viruses had been conquered by the time he made his discovery. Smallpox was the first.

By the 1700s, almost everyone in Europe had either had smallpox or could expect to have it. Smallpox leaves marks on the skin, so it was easy to tell whether or not a person had had the disease. It came to be common knowledge that once a person had smallpox he could never get it again. In fact, special hospitals were set up to give people smallpox on purpose to ward off future accidental attacks that might be more serious.

Cows also often got a disease that caused pock marks like those of smallpox (if you remember having had the chicken pox, you know what a pock looks like). Country people often said that a dairymaid or farm worker who had been exposed to cowpox would never get smallpox.

Edward Jenner, an English country doctor, respected what the farm people said. His observations over many years confirmed the rumors that cowpox offered a protection against the dreaded smallpox. Finally he decided to make the crucial test. On May 14, 1796, he scratched a little fluid from a cow pock onto the skin of a young farm boy named Jamie Phipps. (A child *had* to be the hero of this experiment because almost every adult in England at that time had had some form of pox.)

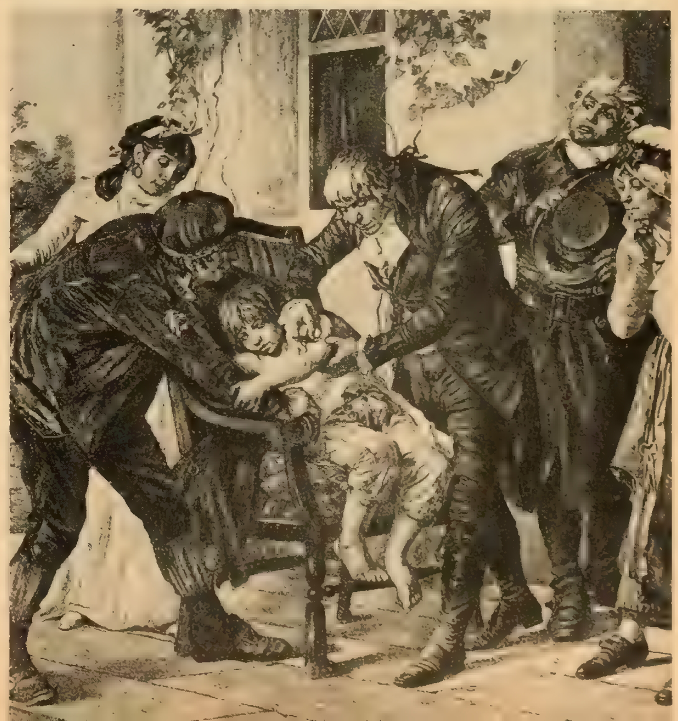
Jamie felt a little feverish for a day or two, but he recovered quickly. Then, on July 1—and this was the history-making experiment—Dr. Jenner scratched a little smallpox fluid on both of Jamie's arms. Nothing happened at all; not even a tiny mark appeared. Jamie was protected against smallpox. Dr. Jenner called his cowpox fluid *vaccine* ("vacca" is the Latin words for cow).

Vaccination worked, but no one even began to understand why for almost one hundred years. Then the great French scientist Louis Pasteur began to realize that cowpox, which is a mild illness, protected people against smallpox, which is a dangerous illness, because the two diseases are so much alike. In fact, as Jenner had sug-

(Continued on the next page)

Scientists are constantly trying to make vaccines that provide longer protection with less chance of discomfort to the person who is vaccinated. This girl is receiving a new measles vaccine developed by Pitman-Moore Company.

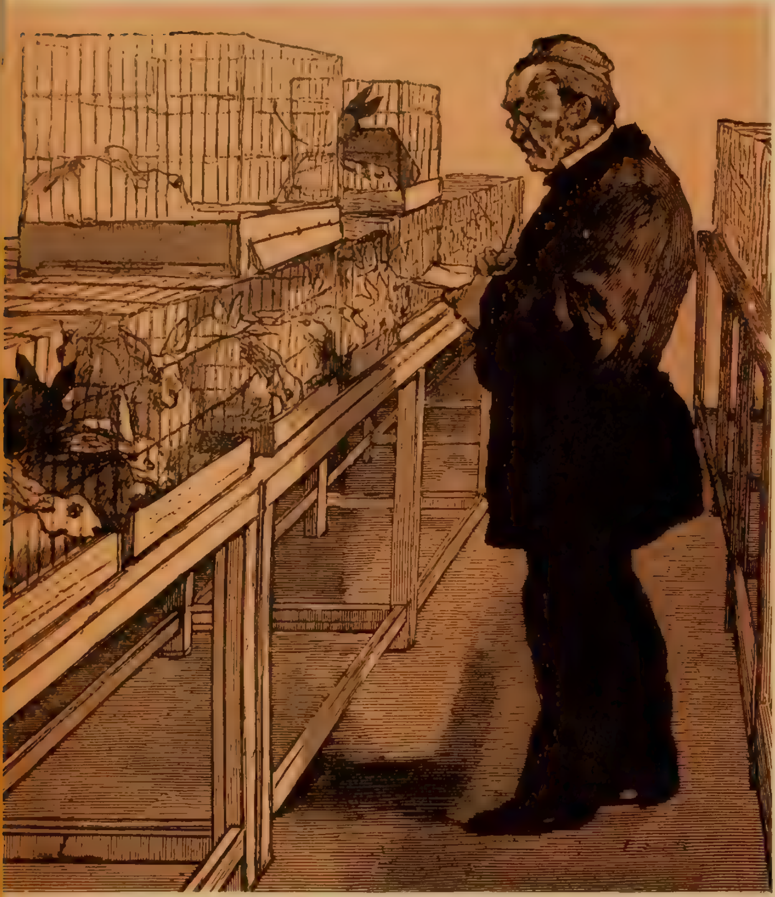
This early print shows Dr. Jenner vaccinating Jamie Phipps.



gested, cowpox is smallpox that has been "tamed" by growing in cows.

Taming a Virus

In Pasteur's day, one of the most feared diseases was *rabies*, or hydrophobia. This disease is transmitted through the bite of a dog or other animal that has been made "mad" by the infection. Rabies is a fatal disease (in fact, we now know that rabies is the only disease caused by viruses that will always kill an infected person unless he is given the proper treatment).



Louis Pasteur is shown in his laboratory with some of the rabbits he used to develop a "tamed" rabies virus.

Pasteur found that the saliva of "mad," or rabid, dogs could be used to give other animals the disease. He searched this fluid with his microscope, but he could not see what caused rabies. Nevertheless, he set out to change whatever it was just a little—to tame it in order to produce a vaccine.

By infecting a series of rabbits, each one with fluid from another, Pasteur finally obtained a fluid that seemed a bit less poisonous that the usual fluid from a rabid dog's saliva. He injected this fluid into some healthy dogs, in slightly stronger doses each day for two weeks. When the dogs were given full-strength doses of the fluid, they did not develop any signs of the disease.

Rabies develops slowly, in humans as well as in dogs, so Pasteur thought his vaccine might even work after a dog had been bitten by another dog that had rabies. His experiments proved this true, also.

But while Pasteur's vaccine worked in dogs, he did not know whether he had really changed it enough to make it safe for humans. In July of 1885, a Madame Meister appeared at his laboratory door with her nine-year-old son Joseph. Joseph had been bitten two days before by a dog that was infected with rabies. Pasteur's fellow scientists advised him not to give his vaccine to the boy. If the boy died, they argued, people would say that Pasteur's vaccine had killed him, and his great scientific reputation would be destroyed.

Pasteur called in doctors to examine Joseph, and they reported that the boy had no chance to recover. Pasteur felt he had no choice. He gave the boy small doses of the vaccine, in increasing strengths, every day for 12 days. And Joseph Meister lived.

Today there are many vaccines to protect us against many types of viruses, such as yellow fever, measles, polio, and influenza. All of these vaccines were first made in much the same way that Pasteur made his rabies vaccine.

Scientists are continually trying to improve these vaccines. For example, the rabies vaccine made from the brains of infected rabbits can only be given in a series of 14 doses, and it has in rare instances paralyzed people or even killed some. For this reason, it is given only to persons who are known to have been exposed to rabies. A new rabies vaccine developed by scientists at Eli Lilly and Company has just been approved by the Federal Government. It does not contain the substance in rabbit-tissue vaccine that can cause paralysis, so it can be given in three or four doses to persons who might come in contact with rabid animals, giving them advance protection.

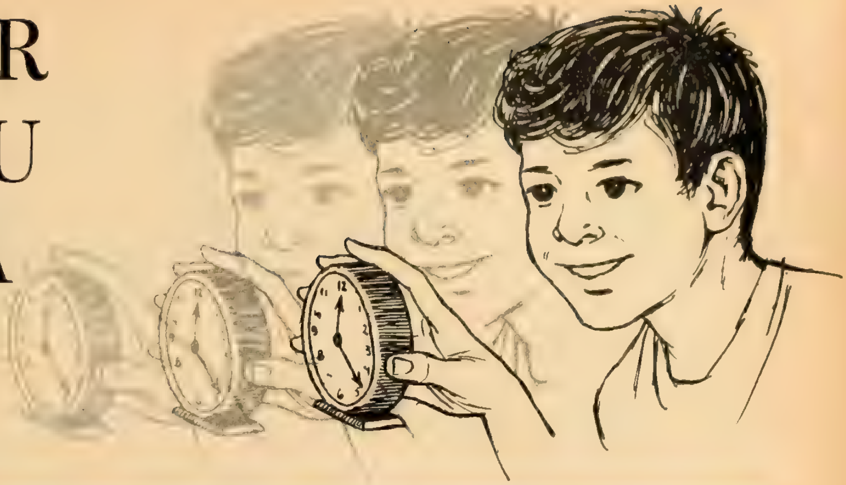
We know now that vaccines work the same way as a natural infection does to prevent future infections by the same kind of virus. After a natural attack by a polio virus, for example, the defense system of our bodies instantly "recognizes" that kind of virus the next time it enters the body, and destroys it. A tamed polio virus closely resembles the natural virus, but it will not cause the disease. So the tamed virus can be safely injected into your body, where it "trains" your defense system to recognize the natural virus and destroy it as soon as it appears ■

(Part 2 of this article, in the next issue, tells what we have learned about viruses in this century and explores the question of whether viruses are living things.)

SCIENCE WORKSHOP

HOW FAR CAN YOU HEAR A TICK?

by David Whieldon



■ Every day you hear a fascinating variety of sounds—voices, automobiles, running water, barking dogs, and music, for example. You depend on your ears to get information, to hear pleasant sounds, even to get warning of danger. Have you ever wondered just how good your hearing is?

You can find out by doing some simple investigations. First, get a kitchen timer or a clock that has a loud tick. Then, ask a friend to stand about three feet from you, holding the clock or timer. If you can hear it, tell him to move back another foot. Keep doing this as long as you can hear the ticking sound. When you can't hear it, tell him to move slowly toward you. As soon as you can hear the ticking again, measure the distance between you and him. Write this figure down.

Now ask your friend to hold the clock at different distances while you cup your hand behind your ear. Once again find the greatest distance at which you can hear. Can you hear farther now than before? Make a paper cone, hold it to your ear *(see diagram)* and listen for the clock tick once more. Can you figure out why the cone helps you to hear better?

Once you have tested your own hearing in this way, see how well your friends and parents do on the same tests. Be sure to keep notes on your findings. Compare the hearing of different people. Do the young people you test hear better than the older people?

Messages from a Fork

Usually the sound waves made by vibrating objects travel to our ears through the air. But sound also travels through solid materials. If you hold a table fork in your hand and strike the side of it against something hard, the prongs vibrate. Hold the fork about four inches from your ear. Can you hear the vibrations through the air?

Now strike the fork again and quickly hold the *handle* tightly against the bone just behind your ear. Do you hear the vibrations any better?

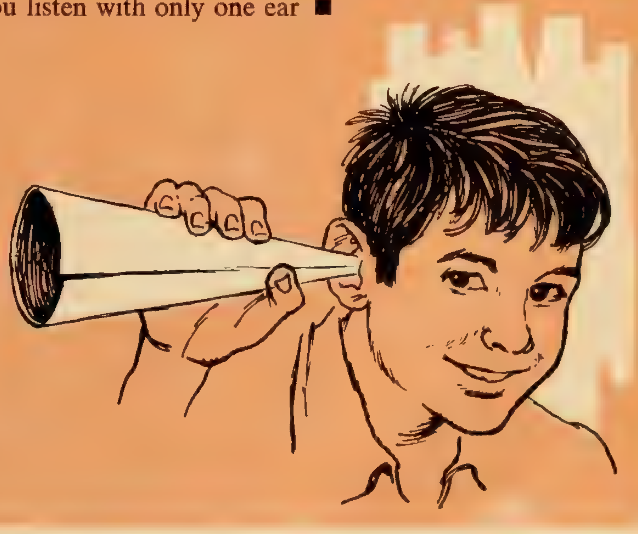
The bones of your head carry the vibrations to your inner ear, where nerve cells pass them along as "messages" to the brain. The bones carry sound waves better than air does. This is the reason why some people wear hearing aids placed against the bones behind their ears.

Where Does the Sound Come From?

Another way to test your hearing is to see how well you can hear sounds from different directions. First have a friend blindfold your eyes. Then have him stand a few feet away and click two quarters together by holding one in each hand and then striking them against each other. Point in the direction you think the sound is coming from.

Have him move around *(quietly)* and click the quarters in different places. Try to point where you hear the clicks. Do you always point in the right direction? Do you hear the clicks best from the left, the right, ahead, or behind?

If sound waves strike both of your ears at the same time, you may have trouble locating the sound. But if sound waves strike one ear before the other, your brain can tell the difference. Try locating the direction of a sound when you listen with only one ear ■



CAN A FLOOD DROWN A PLANT?

Plants need water to grow, but what happens when they get too much? Here is how you can find out.

by Richard M. Klein

■ In the spring and summer of 1965, the western and midwestern parts of the United States had some of the worst floods in history. The Missouri, Mississippi, Ohio, Platte, and other rivers rose 15 to 20 feet, flooding the lowlands for many miles. Whole towns were covered with several feet of water, houses floated away, and newspapers reported that the damage totaled millions of dollars.

If you had traveled through these lands several months later, you would still have seen a few signs of the past floods—battered bridges and uprooted trees, for example. But you would also have seen some trees and bushes that were slowly dying. The trees were not smashed or uprooted, but the flood waters had killed them.

A Flood in Your Kitchen

Why did the plants die? You can investigate this question in your own home, and you don't have to wait for a flood to come by. In fact, it is sometimes better to run experiments in a laboratory rather than in the field, where you cannot easily control the temperature, light, and other factors that might affect your results.

One of the best plants to use for this investigation is the common Coleus plant. You can buy it in almost every florist's shop and dime store in the country. You will need at least a half dozen plants. Try to get plants that are the same size and color, and that have the same leaf pattern. Plants of different sizes and colors may also live and grow in different ways. By using plants that are as much alike as possible you can be more sure that you are testing only the effects of flooding.

Each Coleus plant should be growing in a small pot. You can make "flood areas" from one quart cardboard

The trees and shrubs near these houses may die several months after being flooded. You can find out why by "flooding" some plants in your home.

milk cartons with the tops cut off. Set one potted Coleus plant in each carton. Then add different amounts of water to four of the cartons. The diagrams on this page show how much water to add. Put a fifth plant in a carton but do not add any water. Set a sixth plant near the others but do not put it inside a carton.

Cover the open tops of each carton with a plastic bag held in place with rubber bands. This will keep the water from escaping into the air as vapor *(evaporating)*. By doing this you won't have to add water during the investigation. Place all of the plants near a window or somewhere else where light can enter the cartons. Every two or three days, water the two plants that are not "flooded," as you would water any house plant.

After two weeks, take the plants out of the cartons and look at them closely. Are they all healthy? Have they lost any leaves? Look at the green and red areas of the leaves. Are they the same color as those in the plants that were not "flooded"? Has flooding affected the height of the Coleus plants or their number of leaves?

You will probably find that flooding affects some of the plants more than others. Can you figure out why? Might it have something to do with the oxygen gas that green plants need for life?

After the Flood...

This gives you an idea of the ways plants are affected *during* a flood. Now, what happens after the flood waters have receded?

To find out, simply let the Coleus plants grow outside of the cartons for a few more weeks. During this time, of course, you should give all six plants normal care and sunlight. They should be watered lightly every second or third day. At the end of each week, look at the plants again. Have the damaged plants begun to recover? Are any of them dying? Compare their growth with the plants that were not flooded.

You may be able to test other Coleus plants with different kinds of "flood" waters. You can take tap water and add some clay to it so that the water becomes muddy. Put some plants in the muddy water as you did before. Be sure to let a couple plants grow normally so you can compare them with the flooded ones. What effect will muddy water have on the amount of light that reaches the plants?

Some floods near the ocean include salty water (such as along the Atlantic seaboard after a hurricane). You can make the water salty by adding four tablespoons of salt to every quart of water. Find out how well Coleus plants would survive a flood of salty water ■

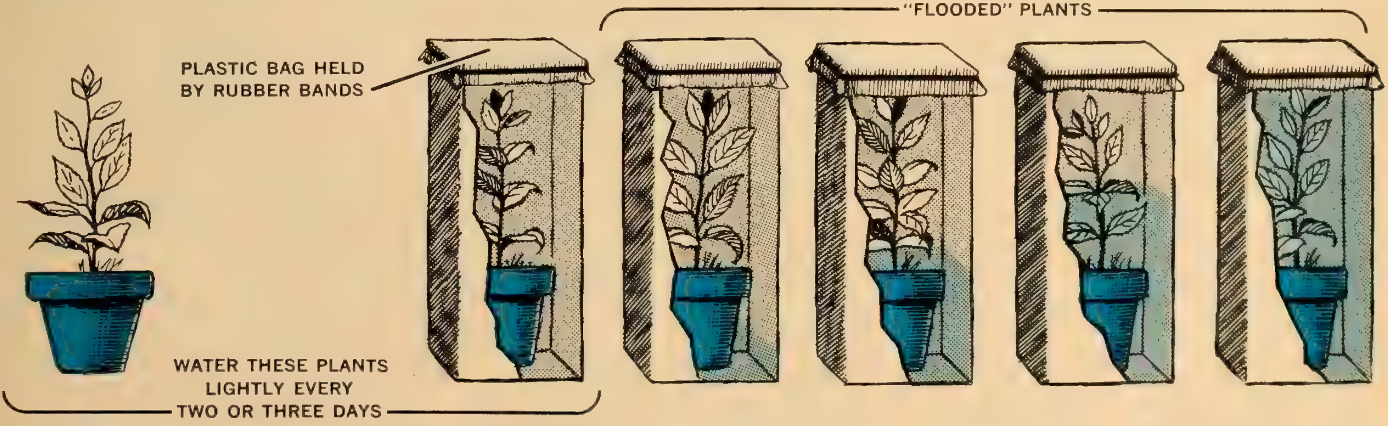
KEEP YOUR INVESTIGATION UNDER "CONTROL"

"Why buy six Coleus plants?" someone asked us. "You only have to flood four. What good are the other two?"

If you have tried other investigations in past issues of *Nature and Science*, you can probably answer these questions. For example, think of the plant that is not placed in a milk carton. To learn anything about how floods affect plants, you must be able to compare the flooded plants with a plant that is growing normally. The plant left outside of the carton is called a "control."

The plant that is put into a carton but not flooded is another kind of "control." Remember, you are doing two things to the flooded plants: 1) putting them in milk cartons, and 2) flooding them. By putting a plant in an unflooded carton, you can find out how this affects a plant. Then you can compare it with the flooded plants.

Dr. Richard M. Klein is Caspary Curator of Plant Physiology at the New York Botanical Garden.


"FLOODED" PLANTS
PLASTIC BAG HELD BY RUBBER BANDS
WATER THESE PLANTS LIGHTLY EVERY TWO OR THREE DAYS

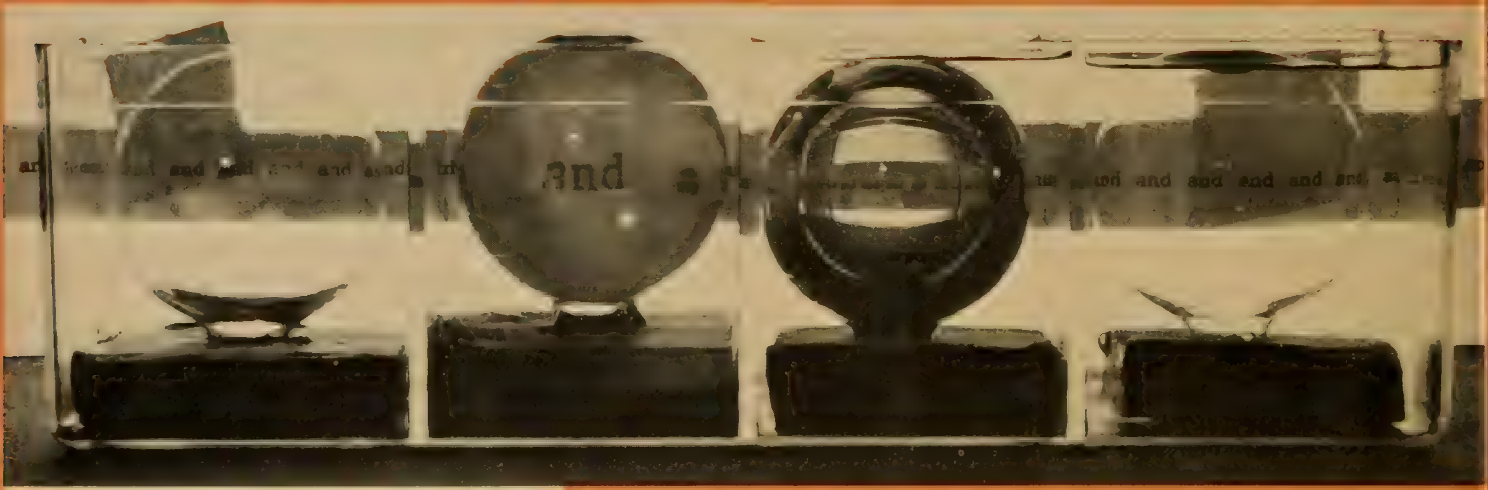
To set up your investigation, cut the tops from five cardboard milk cartons and set a Coleus plant inside. These cutaway views show the amount of water to add to the cartons. Put plastic bags over the tops of the cartons to keep water from evaporating. After two weeks, compare the four "flooded" plants with the other two.

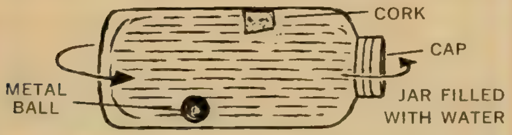
BRAIN-BOOSTERS

prepared by **DAVID WEBSTER**

MYSTERY PHOTO

Some of the plastic globes were filled with water and others have just air. Water was also put into two of the box sections. Which globes and which box sections contain water? (Notice that some letters appear to be different sizes.)





WHAT WILL HAPPEN IF?

What will happen if this jar is spun around? The metal ball will go to the cap end, but the cork will not. Where will it go?

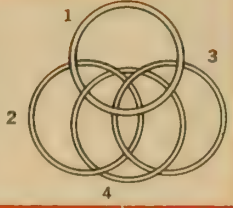
FOR SCIENCE EXPERTS ONLY

When seen from the earth, which planet looks biggest?

FUN WITH NUMBERS AND SHAPES

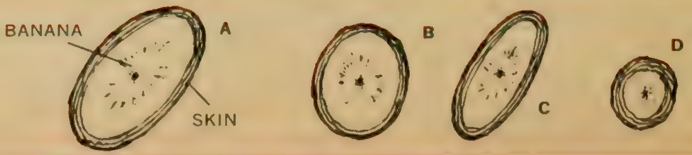
Which ring would you cut to make all the other rings come apart?

Submitted by Carl Emont, Granville, Ohio



CAN YOU DO IT?

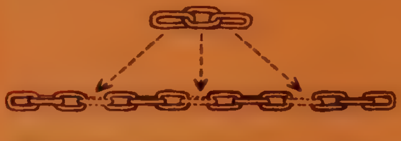
Here are slices cut from a banana with its skin still on. Can you make slices that will look like each one?



Answers to Brain-Boosters appearing in the last issue

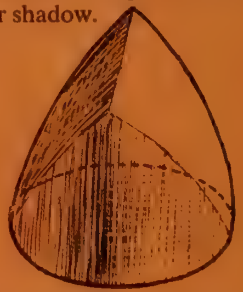
Mystery Photo: The wasp nest is square because it was made inside the wall of an old house.

Can You Do It? The cheapest way to make the long chain would be to take apart one section and use the three links to join together the other four sections of chain.



What Will Happen If? The bucket of water with the log floating in it will weigh the same as the other bucket of water. The weight of water that overflows when the log is put in is equal to the weight of the log.

Fun with Numbers and Shapes: The shape shown below could make a round, a square, and a triangular shadow.



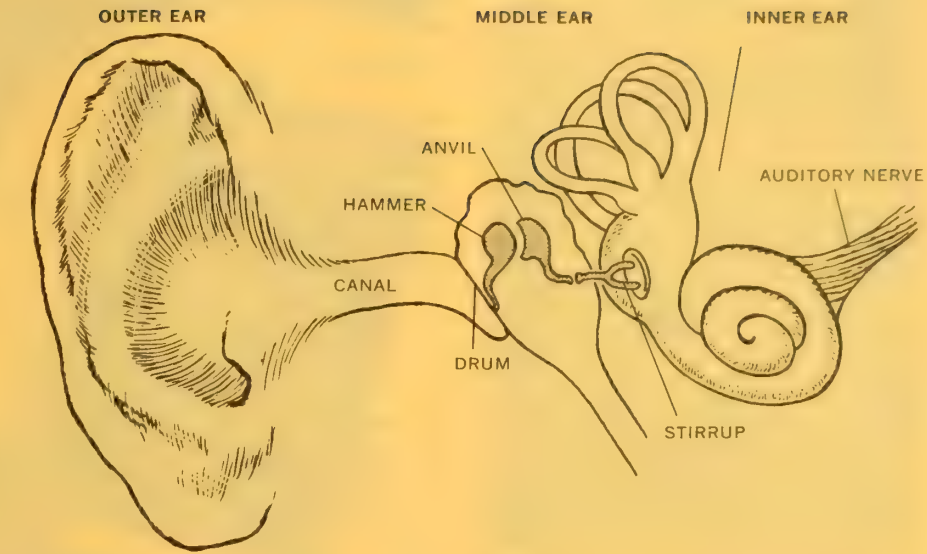
For Science Experts Only: It takes the earth a long time to heat up. Even though the sun is a little farther away from the earth in July and August, the weather is warmer because the earth has had more time to get warm.

Using This Issue . . .

(continued from page 2T)

Most people say it is not, that "sound" is the effect produced on an animal's nervous system by the vibrating air. The falling tree would produce sound as long as there was an animal with hearing apparatus (such as humans, squirrels, mice, insects) to detect the vibrations.

- *People differ in what they can hear.* As people get older they usually lose their ability to hear the highest pitches. Some people can't hear certain sounds such as a cricket's chirp or the calls of certain birds. Injuries may lessen a person's sensitivity. A clap on the ear when he was a boy made Edison hard of hearing for life. Diseases may also affect a person's hearing, and infections in and around the ear may temporarily affect hearing.
- *Hearing aids.* The old-fashioned ear trumpet was just a funnel to collect and concentrate sound waves entering the ear. Electronic aids today intensify the vibrations (as the fork described in the article did when it was held against the bone behind the ear), or they act as a miniature loud speaker close to the ear drum.



Sound waves are collected by the outer ear, and funneled through the ear canal to the ear drum, which vibrates in sympathy with the sound-producing sources. The three smallest bones of the body—hammer, anvil, and stirrup—reinforce and transfer these vibrations to the inner ear, where they are picked up by the endings of the auditory nerve. The signal is carried to the brain, where it is interpreted as sound.

- *Directional information from sounds.* By turning your head from side to side your two ears can detect differences which help you to locate the source of a sound. You can judge distance better with two eyes than with one *(see "Do You Ever See Double," N&S, March 21, 1966).* Similarly you can judge sound direction better with two ears.

Turning Discovery into Thought *(continued from page 1T)*

on their individual discoveries, the teacher might suggest: "Let's collect the facts you've discovered and list them." He heads four columns on the chalkboard as shown below, then says to the children, "Suppose each one of you who has his apparatus balanced tells us the numerals we should write in the columns." The children then dictate the numbers as shown.

NUMBER OF HOLES FROM CENTER	NUMBER OF CLIPS TO BALANCE	NUMBER OF HOLES FROM CENTER	NUMBER OF CLIPS TO BALANCE
2	4	4	2
3	2	2	3
3	4	2	6
1	6	3	2
2	10	5	4

The teacher stops at this point and asks: "Can anyone find a pattern?" He waits. An absorbed silence lasts 30 seconds. Suddenly Alfred shouts, "You multiply!" "Multiply what?" asks Rose. Alfred explains.

"Does Alfred's idea work for all our examples?" asks the teacher. "It doesn't work for mine," says Rose. "What numbers can we use to record your balance?" the teacher asks. "I don't know how to say it, quite." All the children are now concentrating on Rose's problem, as she brings her balance to the front of the room.

"I know how it is," says Tom, "it's 5 and 3 in the right hand columns and it's like all those are on 2½ on the left side." The cloud lifts from Rose's face. She calculates slowly. "Three fives are fifteen. Six times two and a half . . . three and twelve . . . that's fifteen too. It really works."

"Can you put into words what really works, Rose?" queries the teacher.

Rose thinks for a moment, then articulates with some hesitation, "When you multiply the number of clips on one side by the number of holes from the center, it balances any arrangement on the other side that comes to the same number."

"That's a crazy way to do it," adds Pearl with a chuckle, referring to Rose's arrangement. The teacher then asks the children to go back to their balances and try to find some more crazy ways to balance the equipment, then to make the calculations to see whether Alfred's and Rose's statements hold true. The children rush back to their tables and develop a long series of intriguing arrangements, which they verify through calculations.

Levels of thought

This record illustrates several stages or levels of thought. There probably is some kind of thought, pre-verbal thought, at the point where Alfred repeated his balancing strategy with another number of clips. The same is probably true when the heavy six-year-old shifted his position on the seesaw.

Pre-verbal experiences of children often lead to communication of the discoveries; for these, appropriate words and sentences have to be found. The first verbal descriptions are often

(Continued on page 4T)

Turning Discovery into Thought

(continued from page 3T)

vague, more of a relational statement than a precise description. When other children make statements about the same phenomenon in their own words, a concordance of meaning and expression begins to appear.

In the above discussion, the teacher helped the children order their facts by writing down in column form the various discoveries expressed in numerals. The need to contribute to this class project forced each child to observe his balance anew and to put his discovery in numerical form.

The ordered summary of the group's discoveries led the children to make a new discovery, more on the abstract level. They found a pattern, a new relation, in their data. This pattern seemed to fit Rose's data until a way was found to put into words the preverbal discovery that Rose had contributed.

And finally when Rose made a statement in a slightly more generalized form, the children were eager to return to their equipment to make new discoveries. This time the discoveries were guided by an idea expressed in words. The new concrete situations created by the children served as a test and evoked predictions.

The idea that free manipulation of materials engenders pre-verbal thought is illustrated by Jerome S. Bruner in his book, *The Process of Education* (Harvard University Press, Cambridge, Mass., 1960, $2.75; paperback, Vintage Press, $1.35) and again stated in his introduction to *Thought and Language* by L. S. Vygotsky (M.I.T., Cambridge, Mass., 1962, $7.50; paperback $2.45): "It is the internalization of overt action that makes thought."

The idea that communication brings into being a higher level of thought and then launches the thinker into more concrete experimentation has been developed both theoretically and experimentally in the abovementioned book by Vygotsky. There's a whole chapter on the "Development of Scientific Concepts in Childhood." I heartily recommend this book ■

(Articles in N&S *about different methods of teaching science do not imply endorsement of any particular method by The American Museum of Natural History.)*

nature and science

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TEACHER'S EDITION

VOL. 3 NO. 16 / MAY 9, 1966 / SECTION 1 OF TWO SECTIONS

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(FOR YOUR CLASSROOM BULLETIN BOARD)

Things You Can Do This Summer

Summer vacation is a great time to do some of the things you've been wanting to do all year but were too busy to do. Here are some things you might like to explore, investigate, and make this summer, and the issue of *Nature and Science* that tells you how to go about it. Have you tried—

Raising houseflies, watching how they develop from eggs to adults, and testing their behavior? *Sept. 20 and Oct. 4, 1965.*

Searching for fossils in your area and in places you visit? Trying to identify them and starting a collection? *Oct. 18, 1965.*

Exploring the world of tiny things with an inexpensive, homemade microscope that magnifies objects 80 times? *Dec. 6, 1965 and Jan. 24, 1966.*

Testing your dog to find out how well he can follow a trail and whether he is "left-handed or right-handed"? *Nov. 15, 1965.*

Growing plants in light of different colors to see what happens to them? *Jan. 10, 1966.*

Setting up a weather station with easy-to-make instruments and finding patterns in the kind of weather that usually comes to your area with certain changes of wind direction and atmospheric pressure? *April 4, 1966.*

Taking a census of the animals in an area by catching and counting only a few of them? *Feb. 21, 1966.*

Making dazzling designs by mixing the patterns you find in everyday things such as combs and screens? *Feb. 7, 1966.*

Taking milk apart to see what it is made of? *Nov. 15, 1965.*

Searching for tiny gems and magnetic minerals in black sand? *May 9, 1966.*

Ripening a green tomato with a ripe banana? *Nov. 15, 1965.*

Finding out what salt does to growing seeds? *March 7, 1966.*

Watching how pets and zoo animals behave toward each other and toward people? *May 9, 1966.*

Measuring waves in your bathtub and finding out how waves move sand and floating objects at a beach? *Dec. 20, 1965.*

Making a siphon and testing it in different positions? *Oct. 4, 1965.*

Looking for "hidden" animals whose color or shape make them blend into their backgrounds? *May 9, 1966.*

Testing your hearing? *Apr. 18, 1966.*

Seeing how long it takes TIM, the matchbox computer, to learn how to beat you at a game? *Apr. 18, 1966.*

Flooding plants to find out how much water it takes to "drown" them? *Apr. 18, 1966.*

Making a cantilever? *Nov. 1, 1965.*

A fire extinguisher? *March 7, 1966.*

Mixtures and solutions? *Jan. 10, 1966.*

IN THIS ISSUE

(For classroom use of articles preceded by ●, see pages 2T and 3T.)

● **Messages in the Animal World**
A zoo scientist tells about his observations of communication among animals, and gives tips that will help your pupils study animal behavior on their next trip to a zoo.

Treasures in the Sand
Your pupils can use gravity, static electricity, and magnetism to separate minerals in black sand.

● **The Hidden Animals**
A WALL CHART shows examples of camouflaged animals and tells how their protective forms and colors may have evolved.

● **"I Have a Virus...", Part 2**
What viruses are made of and how they multiply.

Bones and Skeletons
A 13-year-old boy tells what he has learned by dissecting animals and reassembling their skeletons.

DEADLINE APPROACHING

There's still time to order the *Nature and Science* Summer Issues for your pupils—and receive free books with your class order. (Our letter describing the Summer Issues, along with a class order form, was mailed two weeks ago.)

We have provided with this issue individual order slips for your pupils to show to their parents and return to you for entry on the class order form. Class orders should be mailed by May 15.

This is the last issue of this school year. We hope to serve you and your pupils again next fall.

USING THIS ISSUE OF NATURE AND SCIENCE IN YOUR CLASSROOM

2 Animal Messages

The author emphasizes the importance of interpreting the behavior of animals with caution. Tigers are not stupid humans in fur coats; they are unique animals, with different genetic makeup, different abilities, and different minds than humans. There is no reason to expect tigers to react and behave as humans do.

Another important point in the article is that animals practice only as much discrimination in communication as is useful. Because of this, they often respond to a poor imitation of their visual or vocal "language." The article gives some examples of this; also remind your pupils of the birds that mob models of owls *(see "What Makes It an Owl?",* N&S, *April 18, 1966).*

Activity

Have your pupils report on the vocal or visual "messages" of animals that are familiar to them. For example, what does a dog do when it is challenging another dog? How does a dog or cat appear when it is frightened? What does a bird do when another bird of the same species enters its territory?

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8 Animal Camouflage

All living things are adapted to their environment. The WALL CHART shows just a few examples of one kind of adaptation—the "camouflage" of animals—and tells how this sort of adaptation probably evolved.

Topics for Class Discussion

- One scientist examined the stomach contents of some birds and found many insects that were protectively colored. He concluded that their coloration does not protect these insects. *Ask your pupils what they think of this conclusion. Is it logical? Is there anything wrong with the man's approach to this investigation?*

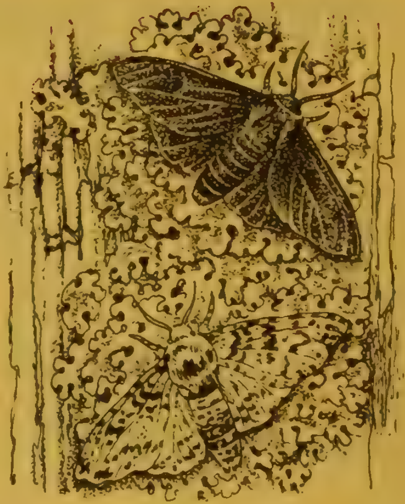
There is one major flaw in this approach: The scientist did not know the relative numbers of camouflaged and uncamouflaged insects in the area where they were caught by the birds. The camouflaged insects may have been more abundant than the uncamouflaged ones. This could account for the large number caught.

No one claims that camouflaged animals always escape their enemies. But, as the WALL CHART mentions, scientists have found that camouflage does tend to protect the animals.

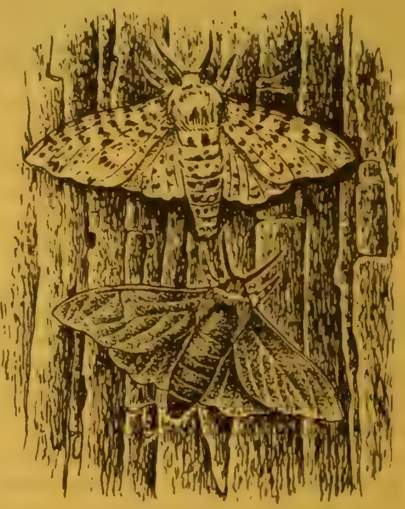
- *How can groups of uncamouflaged animals survive?* Why aren't they all wiped out? Animal camouflage is *one* adaptation for survival that has evolved; there are others. It is useful to survival but not necessary. You might suggest this analogy: The use of refrigerators has spread among human beings, and refrigerators help us survive by keeping our food from spoiling. However, humans can (and sometimes do) get along without refrigerators.

Other ways of compensating for the losses of predation have evolved. For example, some insects and other animals that lack camouflage have high rates of reproduction.

- *What about brightly colored animals?* How do they escape their enemies? The bright colors of many insects serve as *warning colors*. These insects usually have stings, bristles, or unpleasant tastes. After a few experiences with such insects, predators learn to leave them alone; the gaudy colors warn the predators away. A fascinating example of adaptation among animals is the coloration of the viceroy butterfly, which is almost the same as the coloration of the bad-tasting monarch butterfly. The viceroy butterfly is apparently quite acceptable as food, but is shunned by predators because of its resemblance to monarchs. Such protective coloration is called *mimicry* (meaning resemblance, *not* conscious imitation).



ABOUT 1850



TODAY

Before 1850, most of the peppered moths near Manchester, England, were pale in color. Their speckled appearance concealed them as they rested on light-colored tree trunks in the daytime. But as soot and smoke from industries coated the trees, the pale forms were gradually replaced by dark ones. Today the pale forms are rare except in rural areas.

- Even though it often takes thousands or even millions of years for camouflage to evolve, there are a few examples of significant changes evolving over the past century or two. One example is illustrated in the diagrams on this page.

(Continued on page 3T)

nature and science

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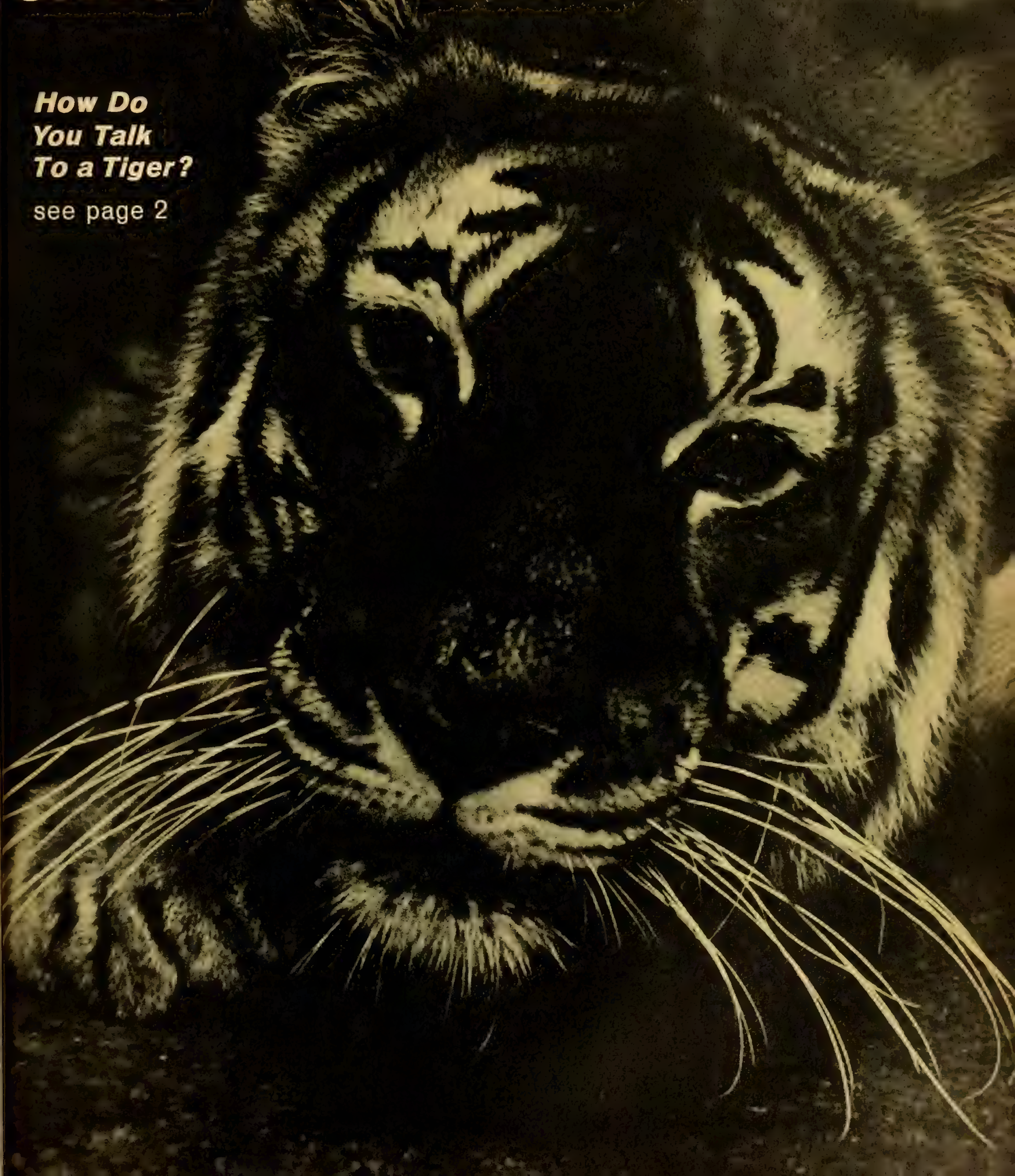
When you walk through woods and fields this summer, you will be surrounded by...

THE HIDDEN ANIMALS

see page 8

How Do You Talk To a Tiger?

see page 2



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A zoo scientist describes his experiences with the language of animals, and tells how you can figure out

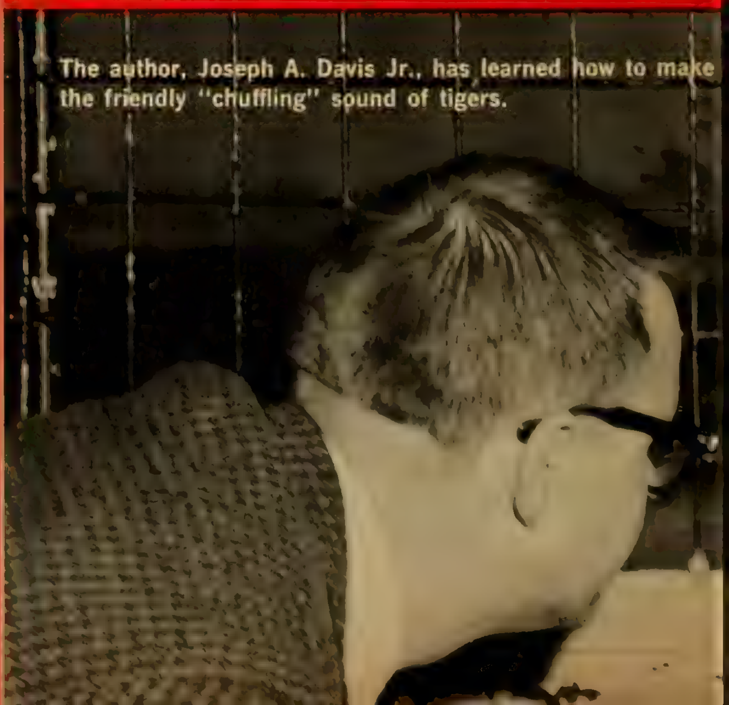
by Joseph A. Davis, Jr.

■ To understand the ways of an animal, you have to try to "get inside" the animal's mind. Some people seem to be able to do this easily. Others must keep training themselves to make this ability work and grow. I think I fall into the last group. In my job as Curator of Mammals at the New York Zoological Park (Bronx Zoo), I have many chances to study the ways of animals. Some of the experiences I've had may help you understand the behavior of animals—not only in zoos, but also in your own home.

People sometimes make the mistake of "putting themselves inside" an animal, expecting a beast to feel in the same way humans do. They think, "What would *I* be feeling now if I were in that tiger's place?" The question should be, "What would I be feeling now if I had *that tiger's mind?"*

To "get inside" the brain of an animal, watch the movements of its body and listen for any sounds it makes. Animals that live in groups, such as wolves and chimpanzees, usually have the best developed ways of showing what is going on in their minds. On the other hand, animals that usually live alone do not reveal their feelings

This article is adapted from an article in the March-April 1965 issue of Animal Kingdom *magazine.*



The author, Joseph A. Davis Jr., has learned how to make the friendly "chuffling" sound of tigers.

Messages in the Animal World

as well. Many a bear has been labeled "treacherous" because it was unable to show its growing anger until it was moved to action.

When I walk within the guard rail of the Lion House at the Bronx Zoo, the jaguars watch me silently, with deadpan faces. But the toes of their hind feet move ever so little–for a firmer grip on the floor. They are making ready for a death-dealing leap. It never comes, because of the heavy wire between us. They know that the wire is there, but they automatically get ready. Only their toes give them away.

The "message" of the flexed toes would be recognized by another jaguar. As far as we know, animals are born with the ability to recognize such signs from other animals of the same kind *(species).* A tiger born in the Bronx understands another freshly imported from India.

"Punch Your Snout?"

The "messages" we send to animals often aren't understood in the way we might think. Dogs, for example, usually jump up and race to the door when you say "want to go out?" They would do the same thing if the question were changed to "are you a lout?" or "punch your snout?"

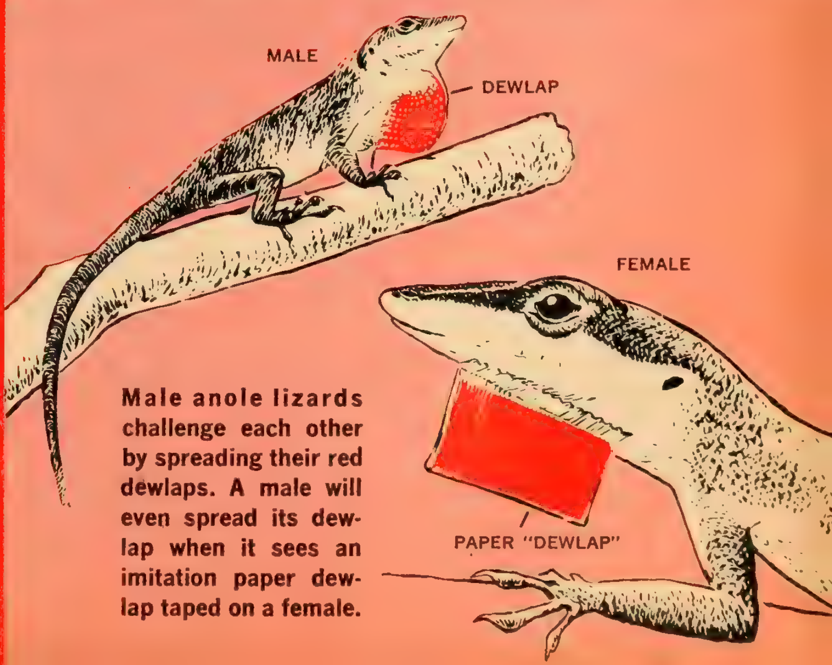
Not that dogs are stupid–far from it. It is just that a combination of the "out" sound and the rising sound of the question mean only one thing in their lives–a chance to romp outdoors. If the question "punch your snout?" were repeated often enough, followed by a real punch in the snout, the dog would soon learn to tell the two sentences apart.

Other kinds of animals also react to poor imitations of their "language." A few years ago, I showed an example of this to some students at Cornell University in Ithaca, New York. We used anoles, the little lizards that are often (and incorrectly) called chameleons. Both male and female anoles have a white throat, but the skin under the scales of the throat is red in the males.

Normally the red color is hidden by the overlapping scales. An aggressive male, however, spreads a flap of skin on its throat–called the *dewlap*–and exposes the brightly colored skin *(see drawing).* Another male, seeing this, responds by spreading its own dewlap.

We used to spread the dewlap of a male and fasten it with cellophane tape. Other males in the cage would then show their red throat patches as soon as they saw him. To top this, we then taped an artificial red dewlap on a female. The males still responded, despite the poor color-

(Continued on the next page)



Male anole lizards challenge each other by spreading their red dewlaps. A male will even spread its dewlap when it sees an imitation paper dewlap taped on a female.

match of our paper dewlap. Within bounds, even the shape of the imitation dewlap could be wrong.

How To Tell a Lizard from a Gum Wrapper

Last year I accidentally caused another animal to react to an imitation of part of its language. I was visiting the Arizona-Sonora Desert Museum in Tucson. It has a big enclosure that contains several species of desert lizards.

One of the lizards—a kind of swift—is gray in color, but the males have a vivid blue band on their sides. The blue bands have the same effect as the anole's red dewlap—they flash a challenge to other males. Unlike the dewlaps though, the blue bands are always visible. When a male swift threatens another male, it bobs rapidly up and down, in a sort of stiff-legged pushup.

I had leaned over the wall to watch the lizards when I noticed a male swift on a boulder watching me and bobbing madly. Puzzled, I searched for a reason for the swift's challenge. I found it in my hand—a pack of chewing gum with a blue-green cover. The package had been in motion with the unconscious movements of my hands. The color of the package was far from the swift's blue, and the shape was also different from the shape of the swift's blue band. But a swift in the desert doesn't see anything that is blue and in motion except another male swift. Once I caught on, I deliberately bobbed the package up and down. The swift became more and more excited. Perhaps with experience the swift would have learned to tell the package from another male swift. I couldn't stay long enough to find out.

Talking to Tigers

The arrival of two Siberian tiger cubs at the Bronx Zoo gave me another chance to study the language of animals. The young tigers were sent to us from two other zoos and had never met. They were kept apart for a few weeks until we were sure that they were eating well. When the time came for them to meet, we stood by anxiously. Introducing strange animals can be a quiet, peaceful time—or a bloody battle.

When we opened the door between the tigers they fell upon each other, rolling and tumbling—and "chuffling,"

On Your Next Trip to the Zoo

A trip to the zoo can be more than just an opportunity to see strange animals. If you keep your eyes and ears open, your visit can also open to you the fascinating world of animal behavior.

Most animals spend some of their time resting, so you may see them at rest, doing nothing at all. At other times, though, animals kept together in pairs or larger groups are reacting toward one another, or to the visitors, or to the keeper. Sometimes it is difficult to tell what is going on if you are not an animal expert. But often the meaning of an animal's actions is clear, and if you spend a little time watching a group you will learn a great deal about the behavior of animals. On your next zoo visit, instead of trying to see as many of the animals as you can, pick out a few exhibits only and stay with each one for a longer time.

Watch a family of baboons. If you watch long enough you may be surprised to find that, like people, monkeys (and other animals) can be either left- or right-handed.

Boss and Baby Baboons

The adult male baboon is the boss of the group. If more than one large male is present the males will "lord it" over the females, even though they give the leader first choice of food and resting places. You may be tempted to think that the females have few rights. This is true where food and comfort are concerned. But if a visitor makes a threatening gesture, it is the males who spring to the defense of the group, just as they would do in the wild.

If babies are in the group you may see a baboon "aunt" babysitting for one of the mothers. Babies aren't old

Next time you're at a zoo, watch the behavior of animals like these mandrills (a kind of baboon). How do the adults and young get along?

a friendly sound of greeting. They got along well, and gradually became more friendly towards humans.

Later the tigers were moved to roomy quarters in the Lion House. On their first day there I tried a doubtful experiment, and to my surprise, it worked. I chuffled at them. And they chuffled back!

Chuffling is used by tigers, remember, as a form of friendly greeting, and probably too, of affection. It is hard to describe in words, but sounds like a stuttering grunt. A chuffle is as near as a tiger can come to purring, but it is never, so far as I know, done for long periods, as a true purr is. I can't master the throaty part of a chuffle, but I am understood by the tigers. My clumsy imitation is close enough to a real chuffle for the tigers to understand.

Shortly after learning to chuffle I had a sobering experience. I approached a strange tiger in the National Zoo in Washington, D.C., eager to try my tiger-greeting skill. Standing before the cage I chuffled confidently. The tiger just stared back. I refused to be discouraged, and stood there for a long time, chuffling. Soon a small crowd gathered, attracted by the odd noises. Feeling a bit foolish, I conceded the day to the tiger.

I've done better with the tigers at the Bronx Zoo. Recently, after making sure there were no keepers or visitors nearby, I leaned over the guard rail at the tiger cage and chuffled. And chuffled. And chuffled. Just as I was about to give up, one cub, then the other, relaxed its snarling expression. Ears that had been pressed back straightened. The tigers slowly approached the front of the cage. One chuffled softly. I put my hand near (but not too near) the wire barrier. One cub approached, still answering my greeting, and sniffed gingerly as the other drew near. The spell lasted an instant, then both ran away.

Since then the tigers have grown in size and friendliness. We chuffle to each other every time I pass them. Some day I may even hail a strange tiger in another zoo again —when no one is around ■

Look in your library or bookstore for these books about animal communications: **The Language of Animals,** by Millicent Selsam, 1962, and **Animal Habits,** by George Mason, 1959, both published by William Morrow and Company, Inc., New York, $2.94 each.

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enough to recognize the special position of the adult males, and the babies will do things to them that older baboons would never get away with. They pull the old males' tails, chew on their feet, and jump on their backs. The older males usually allow this. But let an old male show his displeasure, and all but the very youngest baboon will run away as fast as he can.

Watch the faces of the baboons—their expressions tell a lot about the baboon's moods. A baboon never stares hard at another unless he's daring him to a show of strength. Try staring at the biggest male. If you're lucky he may treat you to a threat, complete with a showing of his enormous teeth and a stiff-legged, bobbing movement (but don't get close enough to the cage for him to reach out at you). If your zoo does not have baboons, you may find something like this behavior in other species of monkeys.

Lion cubs often play with the tuft of hair at the end of an adult's tail. What happens when they bite too hard?

Big and Little Cats

A lion family is another good subject for zoo-watching. As you watch them, compare the things they do with the actions of your family cat (or your neighbor's cat). In spite of the vast difference in size, a lion has a lot in common with a house cat. Look for ways in which they are somewhat alike and ways in which they are different. There will be one great difference, if you're fortunate enough to see a pair of lions with cubs. The father lion, unlike most house cats and all other wild species, takes a great interest in his children.

Lions are the only cats that have a brushy tuft of hair on the tips of their tails. As you watch the cubs you'll be tempted to think that the tuft is there for the cubs to play with—they love to attack it. Watch what a parent lion does when a cub bites his tail too hard.

These are just a few of the things you may see on your next zoo visit. Actually, a world of interesting activities takes place in a zoo every day. Look long and carefully next time—you're bound to be rewarded by new discoveries.—JOSEPH A. DAVIS, JR.

Treasures in the SAND

You can find tiny gems in the common black sand that you sometimes see at beaches and along mountain streams. Here's how to make a collection of zircons, garnets, and perhaps even gold.

by O. Eric Liljestrand

■ The next time you make your way through the dunes toward the booming surf, or pick your way along a mountain stream, you might have a look at something interesting under foot.

Look for places where the sand is dark in color—even black. It is not tar, though many beach strollers think it is and carefully step around the dark patches in the sand. This black stuff is made up of a sparkling family of sands that tend to stick together.

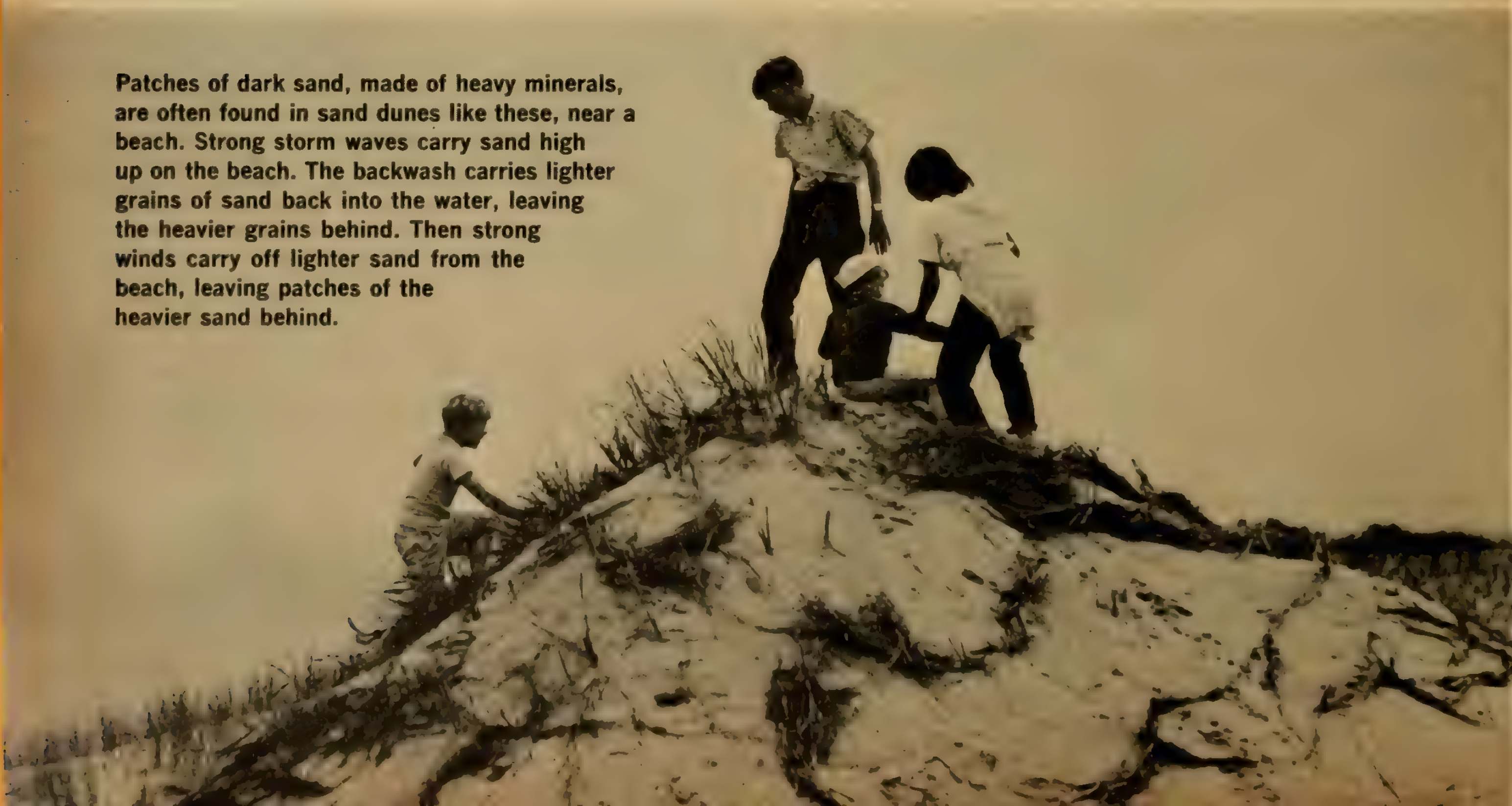
Collect some of the black sand, including as little of the ordinary white, yellow, or gray variety as possible. I usually use a flat pan (a prospector's pan) for collecting at the beach. Sometimes, when it is handier to work at home, I use glass or plastic jars to collect the black sand at the beach, then take it home and "pan" it the way the "49ers" panned their gold.

Pour in about a half inch thickness of sand and then cover it with an inch of water and gently shake the pan back and forth. Because the black sand is heavier than the ordinary beach sand, it sinks to the bottom, leaving the yellow sand on top.

Pour the water off very slowly, until only the sand remains. Then with a spoon remove the layer of yellow sand from the top. You may have to carry out this panning process three or four times until there is only black material left. If you collected enough to begin with, you might want to keep panning until you have a cup or more of clean black sand.

Examining the Sand

If you examine the black sand through a strong magnifying glass, you will find that it is not as black as you thought. Here and there you may find some reddish-brown grains. These are the mineral *garnet*. Other grains that you may find are colorless and long. These are the mineral *zircon*. You may even find a few tiny flakes of yellow metallic stuff that looks like gold, especially if your black sand comes from mountain streams. Chances are



Patches of dark sand, made of heavy minerals, are often found in sand dunes like these, near a beach. Strong storm waves carry sand high up on the beach. The backwash carries lighter grains of sand back into the water, leaving the heavier grains behind. Then strong winds carry off lighter sand from the beach, leaving patches of the heavier sand behind.

that it *is* gold.

Finding gold—if you do—is only part of the fun. There are many ways that you can separate the black sand into several parts. In the panning process, you used gravity to separate the heavy black sand from the lighter weight yellow sand.

Now you can do more separations by putting static electricity and magnetism to work. It is important to use static electricity first because it removes the *non*-magnetic zircons and the *weakly* magnetic garnets from the *strongly* magnetic black sand. Later, you can use a magnet to separate the garnets from the zircons. And after that you can use the magnet to separate the magnetic black sand from the non-magnetic black sand.

Zircons and Garnets

Make sure that the clean black sand is dry. You can dry it by leaving it in the sun for a while, or put it in your kitchen oven at low temperature until the moisture is gone. The "static" process works the same way as picking up bits of paper with a comb that has been rubbed against wool. A very small static electric charge is generated in a spoon when you gently slide it back and forth over the heated sand. The charge attracts zircons (mostly) and some garnets, causing them to cling to the bottom surface of the spoon.

The cluster of tiny gems clinging to the spoon can be brushed onto a sheet of paper with a piece of lint-free cloth or a water-color paint brush. Repeat the spoon process many times, until you have a collection of zircons on your paper. Use the magnifying glass to see if some garnets were picked up with the zircons. If so, you can now use a magnet. Be sure to cover the magnet with a piece of thin plastic wrapping. If you don't use a plastic jacket around your magnet, you will have a hard time removing the grains from the magnet itself.

Stir the covered magnet in the pile of zircons. Garnets will cling to the magnet, but the zircons will not. Drop the garnets onto a separate sheet of paper. You should now have a fairly pure sprinkling of garnets on one paper, zircons on another. These should be transferred to clean pill bottles for safe keeping.

Magnetic Black Sand

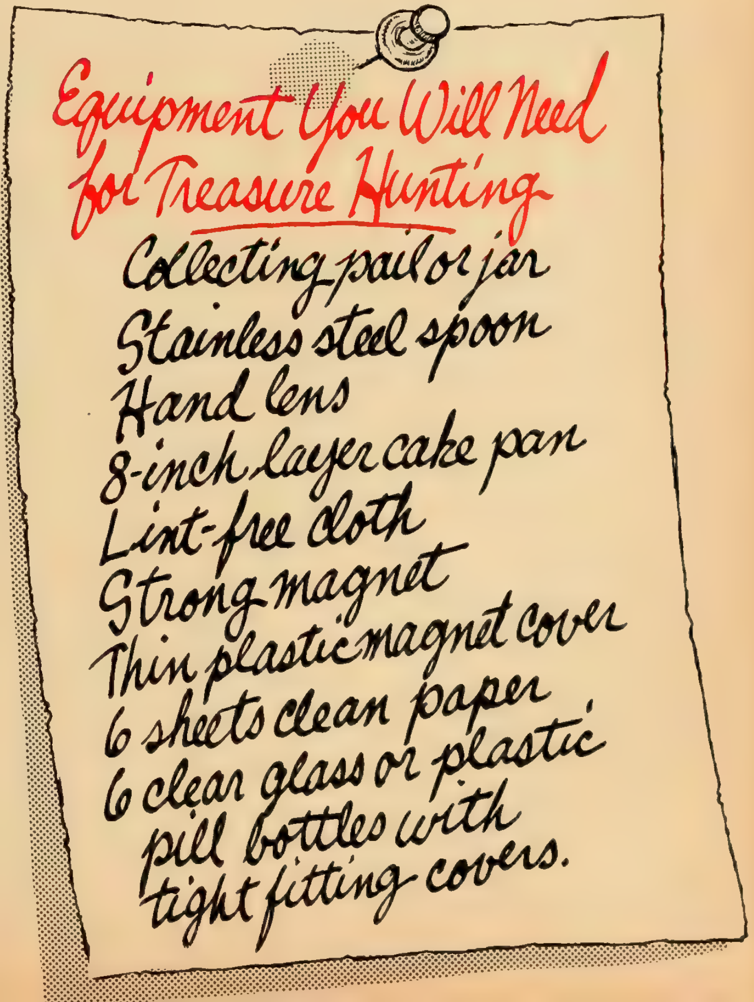
The remaining grains of black sand may be any of 40 or so different minerals. Many of these minerals contain iron, which is attracted to magnets. Now you can match your wits with gravity and try to sort these grains into piles of minerals that are 1) highly magnetic, 2) medium magnetic, 3) weakly magnetic, and 4) non-magnetic.

Stir the magnet around in the black sand, lifting it now and then to transfer its bristling collection to a clean piece of paper. Keep doing this until you have picked up all the magnetic sand. What is left behind is non-magnetic.

Next, hold the clean magnet about an inch above the magnetic stuff spread out on the sheet of paper labeled "Magnetic Sand." (You should label all the sheets and pill bottles as you go along.) Do fingers of black sand reach out of it toward your magnet when the magnet is held at this height? If not, hold the magnet a bit closer to the sand until some of it jumps up to the magnet. This is the highly magnetic material. Form a pile of this stuff and label it "Highly Magnetic."

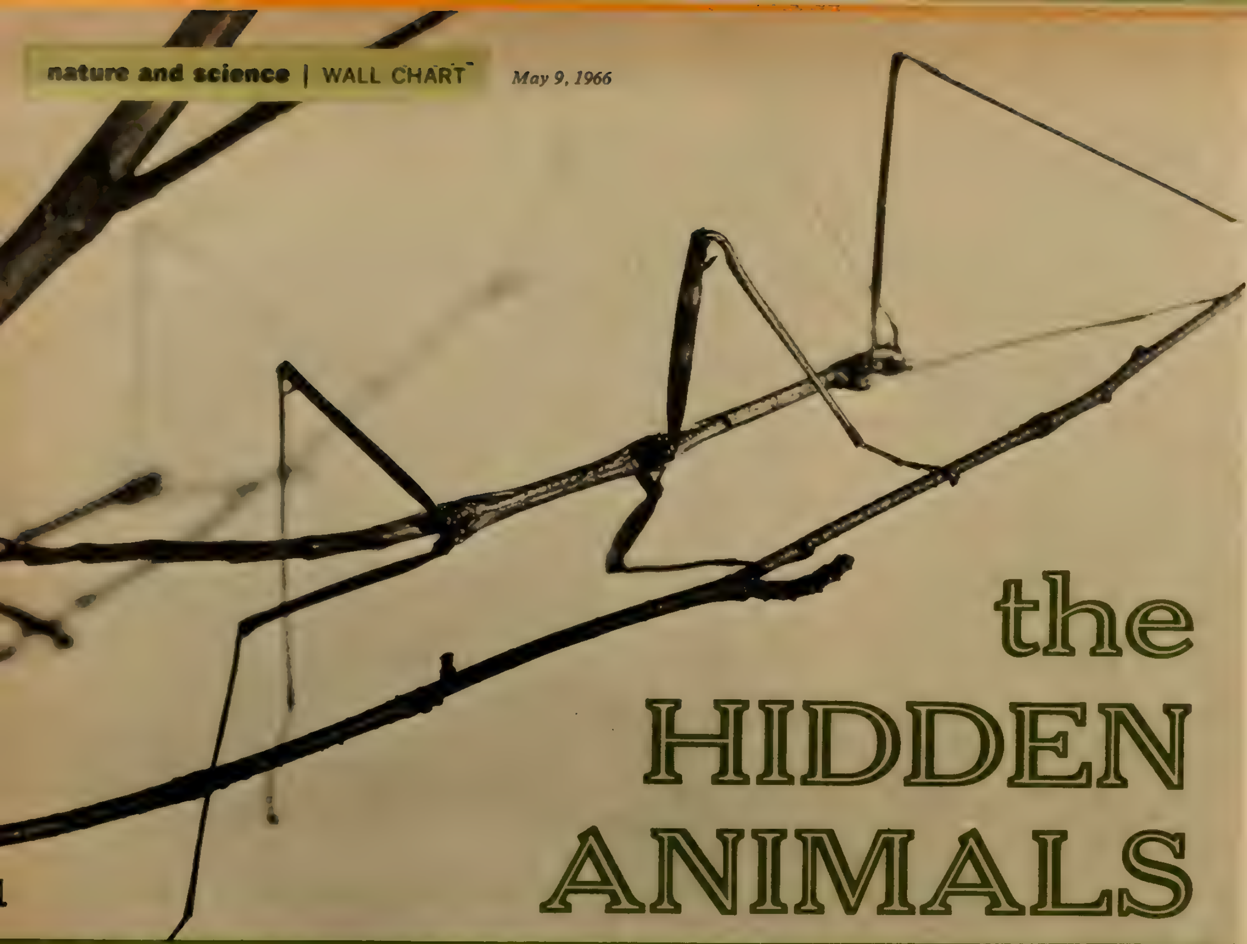
Spread the remaining sand around with your finger and move the magnet a half inch or so above it until you have collected the medium magnetic sand, then label it. What is left is the non-magnetic and weakly magnetic stuff. You should be able to pick up the weakly magnetic sand by stirring your magnet through it.

Look at the list of science tools that you have used: gravity, static electricity, magnetism, and even some hydraulics (panning) to make a collection of zircons, garnets, several magnetic black sands, and even gold. By storing your treasure of tiny gems in capped pill bottles, you will be ready to study them at close hand by using an inexpensive microscope. Happy hunting! Who knows, perhaps you will discover something new in the sand ■



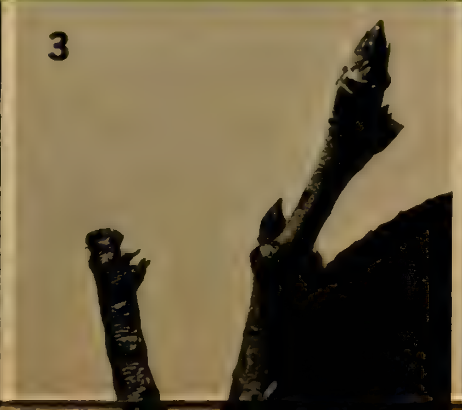
Equipment You Will Need for Treasure Hunting

Collecting pail or jar
Stainless steel spoon
Hand lens
8-inch layer cake pan
Lint-free cloth
Strong magnet
Thin plastic magnet cover
6 sheets clean paper
6 clean glass or plastic pill bottles with tight fitting covers.


1

the HIDDEN ANIMALS

Many kinds of insects have shapes or colors that hide them from their enemies. The walking stick (1) is almost impossible to see when it is resting among twigs. Moths often blend with the bark of trees (2), and some kinds of caterpillars are colored about the same as the twigs of their food plants. When danger is near, these caterpillars "freeze" in the position of a twig (3). Tree hoppers (4) feed on plant juices and often are shaped like thorns. See "How Do Animals Become Camouflaged?" (right).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4

■ As you walk through fields and forests this summer, you will pass close to many different animals. You won't see most of them. Some, of course, are hiding inside holes in trees or in underground burrows. But others are in "plain sight." You miss them because they are *camouflaged*—their color or form blends into their surroundings.

Animal camouflage *seems* to protect some animals from their enemies. Some scientists have asked: Does animal camouflage "work"? Does it really help these animals escape their enemies? To find out, one man set up a dimly-lit "artificial forest," part with a light colored background, part with a dark background. Then groups of mice (some light colored, some dark) were let go in the different areas. Owls were allowed to hunt in these "forests" for a few minutes and a tally was kept on the number and kinds of mice that were caught.

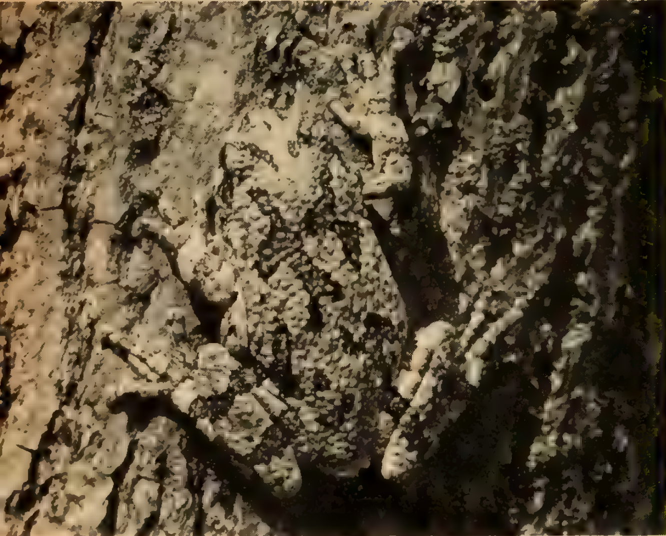
In 13 experiments, 75 of the mice that matched their backgrounds were caught by the owls. But 125 of the other mice were caught. Experiments with fish, insects, and other animals have had similar results; camouflaged animals do survive better than others.

The photos on these pages show some common camouflaged animals. Some of them may live near your home, even in your backyard. See how many different kinds you can find this summer ■

HOW DO ANIMALS BECOME CAMOUFLAGED?

Here is one example of how animal camouflage may have come about. Think of a kind, or *species*, of insect that lives on the twigs of thorny bushes. Each year, some of the new generation of these insects differ a bit from their parents. A few of these insects may be colored or shaped a little like a thorn, and because of this, they are more likely to escape being eaten by birds and other predators. Their chance of surviving long enough to have young is better than that of the insects that do not look like thorns. And the ones that look like thorns pass along their appear-

whenever an insect is born that looks *even more* like a thorn, it will have a greater chance of living and breeding than those that look *just a little* like thorns. The result, after thousands of years, is a group of insects like the "thorn bugs," or tree hoppers (see *photo 4, at left*).

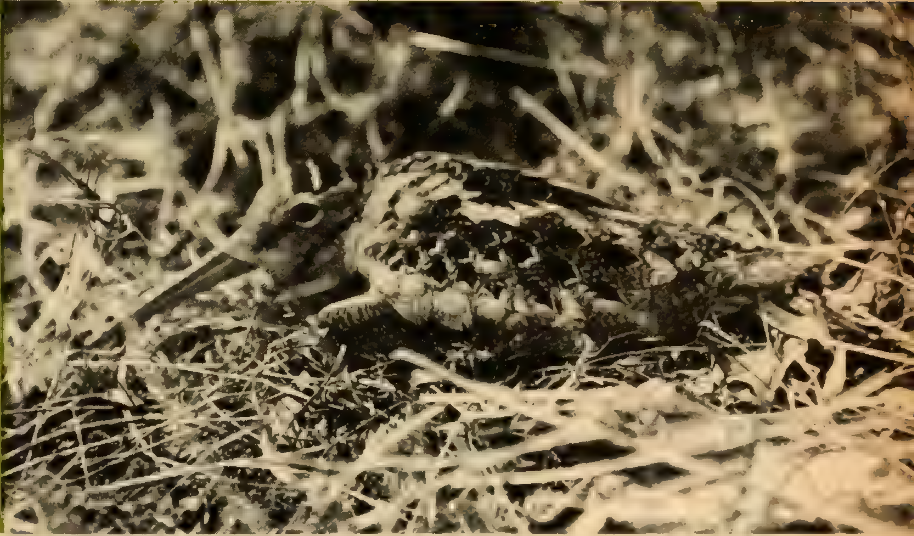


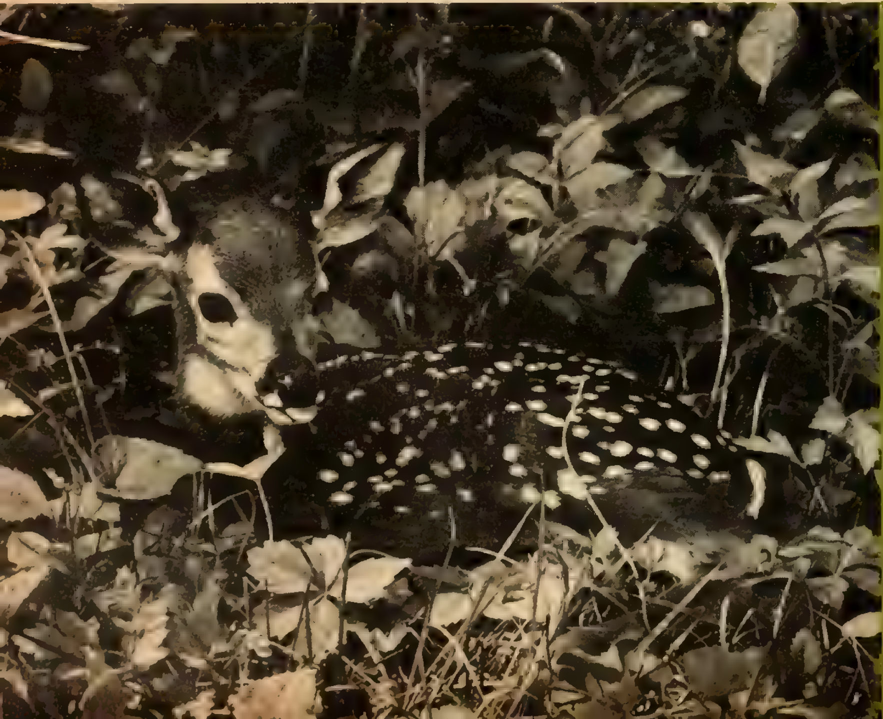
←

Tree frogs cling to shrubs and trees with the sticky pads on their toes. The color of the skin changes—to gray, brown, or green—depending on the frog's surroundings.

→

Birds that nest or feed on the ground usually have colors that blend with their surroundings. The woodcock is a good example. It not only nests on the ground but most of its food is earthworms.





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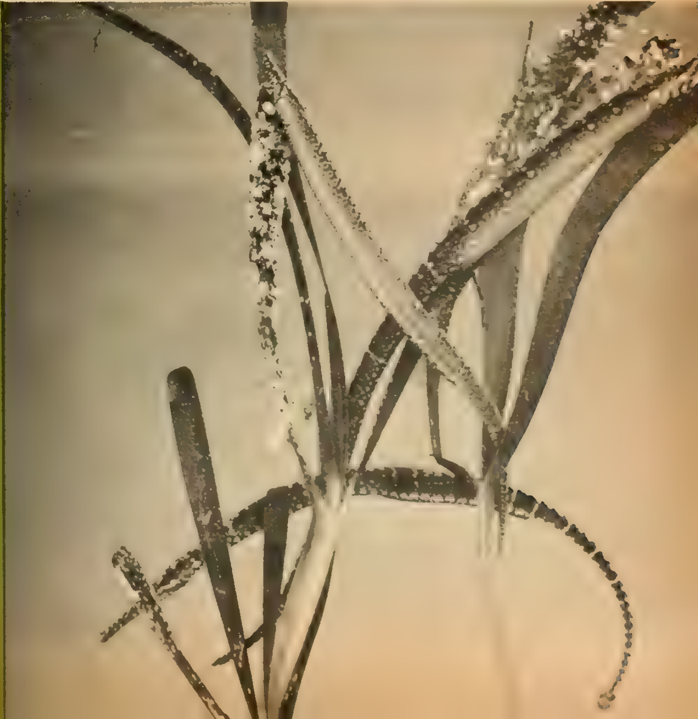
The spots of a fawn's coat are like a patch of sun dapples on the forest floor. In a few months, the fawn will have grown enough to escape its enemies by running. By then the spotted coat will be replaced by a gray-brown one.

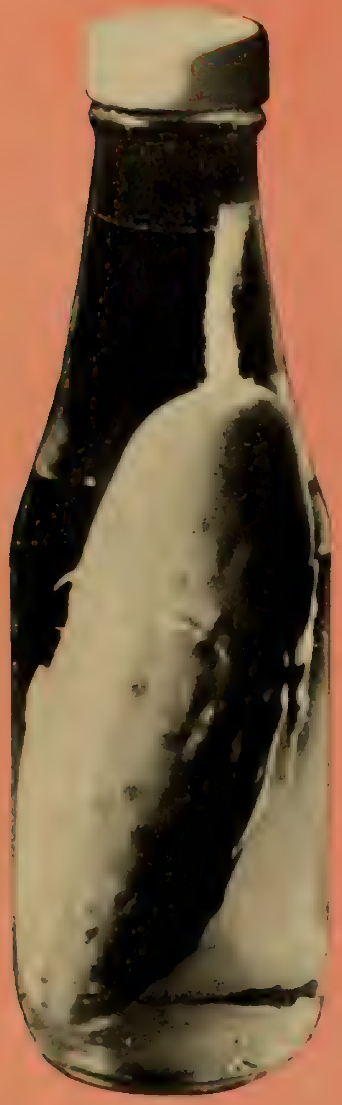
→

These pipefish are shaped and colored like blades of grass. They stay motionless most of the time and swim in an upright position. How many can you find in this photo? Can you think of other kinds of camouflaged fishes?



brain-boosters

prepared by **DAVID WEBSTER**



Mystery Photo

How was the cucumber put into the bottle?

Thanks to Bob Sherman, The Gordon School, E. Providence, R.I.

* * *

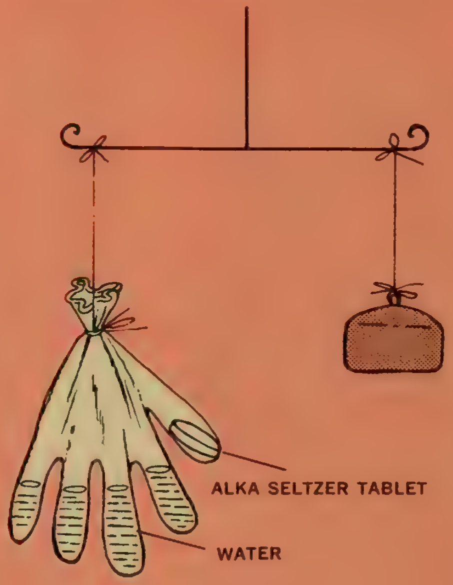
For Science Experts Only

When you are driving along in a snowstorm, why does most of the snow not hit your windshield?

Submitted by Steve Gregory, Lebanon, Ohio

What Will Happen If . . . ?

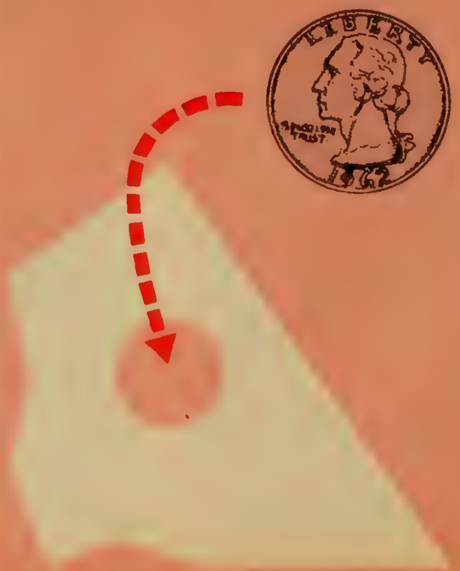
When the water is mixed with the Alka Seltzer tablet, the plastic glove will fill up with carbon dioxide. When this happens, will the scale still balance?



* * *

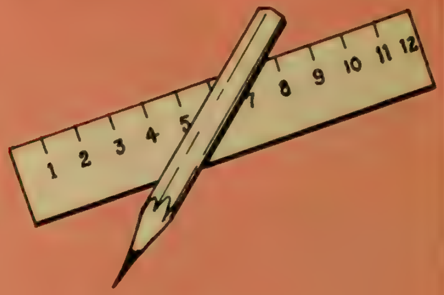
Can You Do It?

Can you put a quarter through a dime-sized hole in a piece of paper?



Fun with Numbers and Shapes

What is an easy way to divide a five-inch space into six equal spaces by using just a ruler and pencil?



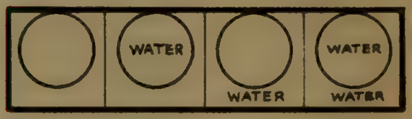
* * *

Answers to these Brain-Boosters are printed on page 16

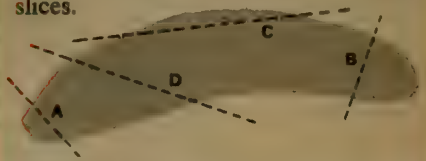
* * *

Answers to Brain-Boosters in the last issue

Mystery Photo: The sketch shows which globes and box sections contain water.



Can You Do It? If you cut a banana (with the skin still on) in the places shown, you should get the proper slices.



What Will Happen If? When the jar is spun around, the cork will stay on top of the water, but will move to the center.

Fun with Numbers and Shapes: If you cut ring No. 4, all the other rings will come loose.

For Science Experts Only: When seen from the earth, the earth looks larger than any other planet.

PART 2

"I HAVE A VIRUS..."

by Helena Curtis

A virus seems to be lifeless until it gets into a living animal or plant. Then it reproduces like other living things. Are viruses alive?

Part 1 of this article told how viruses were discovered by a Dutch scientist, Martinus Beijerinck, in 1898. Beijerinck had proved that a tobacco leaf disease was caused by something in the clear fluid he obtained by crushing diseased leaves and straining them through a filter with tiny holes in it. When some of this fluid was injected into a healthy leaf, it became infected with the same disease (see *photo*) and produced even more of the "poisonous" fluid. Because the poison seemed able to reproduce, or make more of itself, Beijerinck thought it must be "alive." But the tiniest living things known at that time were bacteria, or "germs," that could be trapped in filters and seen through microscopes. Since the tobacco leaf poison passed through Beijerinck's filters and could not be seen with the best microscopes then available, he decided the disease was not caused by bacteria, but by something he called a "filterable virus" ("virus" being then just another word for poison).

The mottled color of these tobacco plant leaves is caused by the tobacco virus, which also makes the leaves brittle.

■ Many years passed after Beijerinck's discovery before scientists began to know anything about the nature of viruses. One of the first clues came when they learned to make filters that would strain out smaller and smaller particles. Virologists—the scientists who study viruses—found that viruses can be caught in filters, and that viruses of different kinds are different in size. For example, the cowpox virus will be caught in the holes of a filter that will let the smaller polio virus pass through. This indicated that viruses had shapes and sizes, even though no one had yet seen a virus.

The scientists also found that viruses can only reproduce when they are inside the tiny living cells that make up plants and animals. And they found that different types of viruses are very particular about the type of cell they grow in. This is why different viruses cause different *symptoms,* or effects.

Cold viruses—of which there are probably 100 different kinds—grow in the cells that line your nose and throat, causing the sniffles and making it hard to breathe. Measles causes spots because the measles virus grows in skin cells. Mumps causes swelling below your ears because the mumps virus settles in the tiny parotid glands located there.

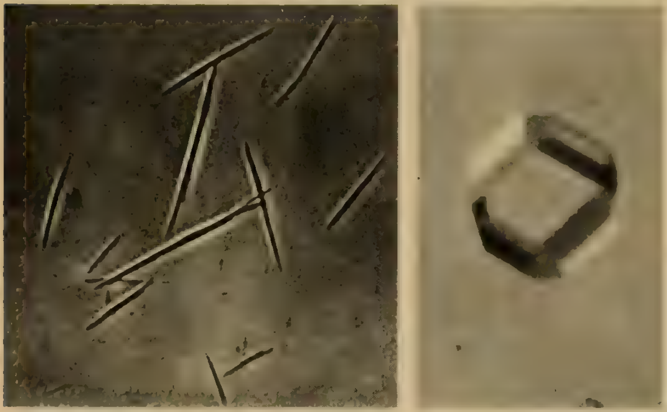
(Continued on the next page)

(As we explained in Part 1, most viruses cause mild diseases and most of these diseases are cured by the body's natural defenses.)

A Teaspoonful of Crystals

Once they knew that a virus is a particle, and not a "living fluid," scientists began to think viruses were not much different from bacteria, only smaller. This seemed reasonable for a time, until an extraordinary discovery was made.

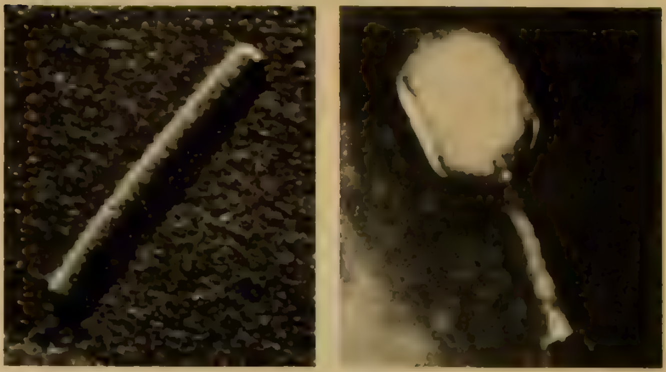
Wendell Stanley, a young biochemist at The Rockefeller Institute's laboratory in Princeton, New Jersey, decided to collect a virus in an absolutely pure form, completely apart from the cell in which it lived. He chose Beijerinck's virus, the one that causes tobacco leaf disease. Dr. Stanley ground up tons and tons of sick tobacco leaves and finally, after months of work, he extracted a teaspoonful of pure virus from them. But he could hardly believe what he saw in this teaspoonful. He had a collection of tiny crystals (*see photos*).



When tobacco virus particles are separated from living cells and dried, they form tiny rod-shaped crystals (left). A polio virus crystal (right) looks like a finely cut gem.

We all know that simple chemicals form crystals—like salt and sugar—but living things are a mixture of many different chemicals. It did not seem possible that anything could be alive and yet be so simple that it would form a crystal. But when Dr. Stanley dissolved the virus crystals in a little fluid, then rubbed the fluid back on the tobacco leaf, the virus multiplied, making more and more viruses.

We know now that viruses can be kept for years as crystals without losing their ability to make more of themselves. Biologists agreed that being able to reproduce was the one characteristic, above all, that showed that something was alive. But few biologists could think of a crystal as being alive. So once more the study of viruses raised the question about the nature of life.



The rod-like object at the left is a single tobacco virus particle. The tadpole-like object (right) is a bacteriophage, a kind of virus that infects bacteria. The photos were made with electron microscopes, which magnify an object several hundred thousand times.

The Shapes of Viruses

Not long after Dr. Stanley's experiment, the electron microscope was invented, a microscope much more powerful than any known before. For the first time, scientists could actually see viruses. The new microscope showed that there are viruses of different shapes as well as of different sizes. Some, for example, are shaped like tadpoles and some like long, thin rods (*see photos*). Many of the viruses first looked like round balls of various sizes. When scientists learned to take better photographs with electron microscopes, each of these round balls turned out to have 20 identical flat surfaces, much like a carefully cut jewel.

Viruses, with all their remarkable shapes, are so tiny that tens of thousands can be spread out on the surface of the single letter "o" as printed on this page.

After the tobacco disease virus had been crystallized, scientists found that it was made of substances called *nucleoproteins*. Proteins, as you probably know, are substances that make up much of your body, and by eating protein foods such as meat, fish, and eggs you help keep your body strong and growing. There are a great many kinds of proteins. Some are known as "nucleoproteins" because—along with chemicals called *nucleic acids*—they are found in the *nucleus*, or central part, of every living cell.

Each tobacco virus particle is a single molecule formed of nucleoproteins hooked together in a certain arrangement. The tobacco virus molecules are all alike. In molecules of different types of viruses, the nucleoproteins are arranged in different ways.

In the early 1950s, scientists made an important discovery about nucleoproteins. They proved that these substances control the way that each living cell grows and reproduces. You, yourself, started life as one single cell—the fertilized egg in your mother. This single cell split apart and formed two cells. Then the two cells split apart, making four cells, and so on. Now you are made up of billions of cells, many of them still growing and making more cells.

In the nucleus of the original egg there were rod-shaped bodies called *chromosomes*. Chromosomes—like viruses—are also made of nucleoproteins and nucleic acids. The way that the nucleic acids were arranged in your chromosomes controlled the way that your cells grew and increased to make you as you are right now. The nucleic acids in your chromosomes are arranged differently than the nucleic acids in anyone else's chromosomes, and because of this, you are different from anyone else.

These chromosomes of yours can do two very important things. First, they can make more of themselves. As your cells divide to make you grow, new chromosomes which are exact copies of the old ones are passed on to each new cell. Every minute there are new cells forming in your body, each with an exact duplicate of the chromosomes that were present in your very first cell.

Second, the chromosomes in your cells produce patterns which guide the cells in making other types of proteins.

Sabotage!

Viruses, too, are made of nucleoproteins and nucleic acids. Because of this, once they get inside cells they can also produce patterns which guide the cells in making other proteins. And what they direct the cells to make are more viruses.

A single virus in fact, is very much like an enemy saboteur. It takes control of the cell, stops its normal activities, and it makes the cell use all its energy and resources to help the virus make more virus. And what an efficient saboteur it is! One virus particle can produce hundreds of new, identical virus particles within a few hours in a single cell. Then the virus particles burst forth, often leaving the cell destroyed, each seeking another cell to begin the cycle anew.

Virus research is teaching today's biologists a great deal about the way in which nucleoproteins control the processes of heredity and reproduction and growth—all processes we think of when we speak of "life." And virus research, of course, is helping doctors find new and still better ways to treat virus diseases. But still scientists have not really decided whether or not viruses are "alive." What do you think? ■

adventures with BONES *and* SKELETONS

by David Granz

Here is the author, David Granz, with his completed turtle skeleton. David is 13 and in the eighth grade. Besides his hobby of studying skeletons, he is interested in astronomy and music. David hopes to become a veterinarian.

■ Did you ever wash a giant snapping turtle in a bathtub? Well, I did!

It all started about a year ago when I decided to make a chicken skeleton for a school science project. I used the instructions in the May 1, 1964, issue of *Nature and Science*. About a week before the project was due, my cat ate some of the back bones, or *vertebrae*. Luckily my mother was able to get another chicken so that I could replace the vertebrae that my cat ate. After I finished the chicken, I put together some more skeletons—a frog, hamster, fish, and a duck's foot. With these skeletons, including the chicken, I won first prize in the seventh grade science fair.

Washing a Dead Turtle

One evening last summer my brother's friend, Doug, called me on the telephone to ask if I wanted a big, dead

(Continued on the next page)

turtle. My mother left her dishwashing and took me to Doug's house.

The turtle was big—but not dead! Its shell was crushed, and it also looked as if the turtle had been shot through the rear right leg. We took it to the office of the Massachusetts Society for Prevention of Cruelty to Animals to have it put "to sleep." Unfortunately no one was there. The turtle died on the way home.

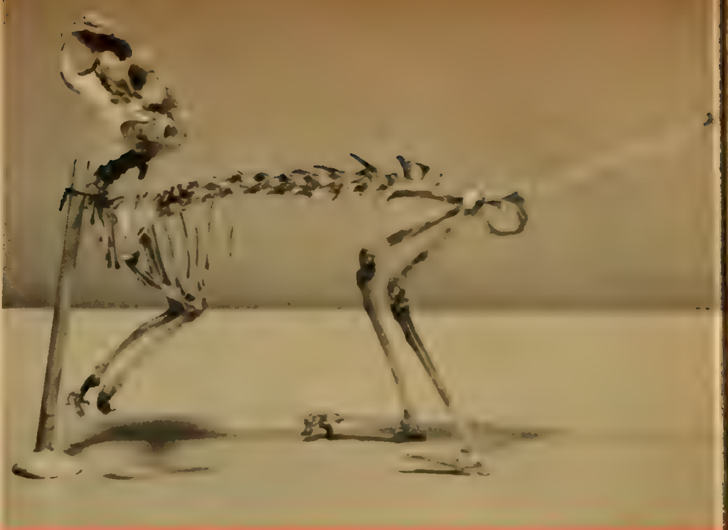
Since I did not know what the turtle had died from, I soaked it in boiling water and bleach to kill bacteria and other "germs." The only place big enough to do this was in the bathtub! After soaking, it was too late to begin cutting the turtle apart. I filled the bathtub with cold water and disinfectant and left the turtle overnight.

The next morning I cut the turtle apart outdoors. I removed the legs, head, and tail, and cooked them in a big canner. Later I cooked the shell in an old washtub. It took me parts of two weeks to clean the meat from the bones. Then I glued the bones back together. My finished turtle skeleton is 40 inches long.

Learning from Bones

On the same day the turtle was cooking, another friend brought me a dead chinchilla. I cooked it and removed most of the meat. Then I froze it, since I was busy working on the turtle. One mistake I made in freezing it was to cramp it into a plastic bag. When it thawed, the neck was still twisted. I couldn't get the neck straight when I glued it together. While I was gluing the chinchilla bones together, my cat again got to the bones, eating one shoulder blade. I molded a piece of clear plastic to replace the missing bone.

I've learned a lot about animals and their skeletons since I began this study. For one thing, I've learned to recognize different kinds of *joints* (where two bones join). I noticed a difference in the hinge joints of a chicken's toe and a duck's toe. The duck's toe is curved around farther than the chicken's. This enables a duck to bend its feet more as it paddles through the water.

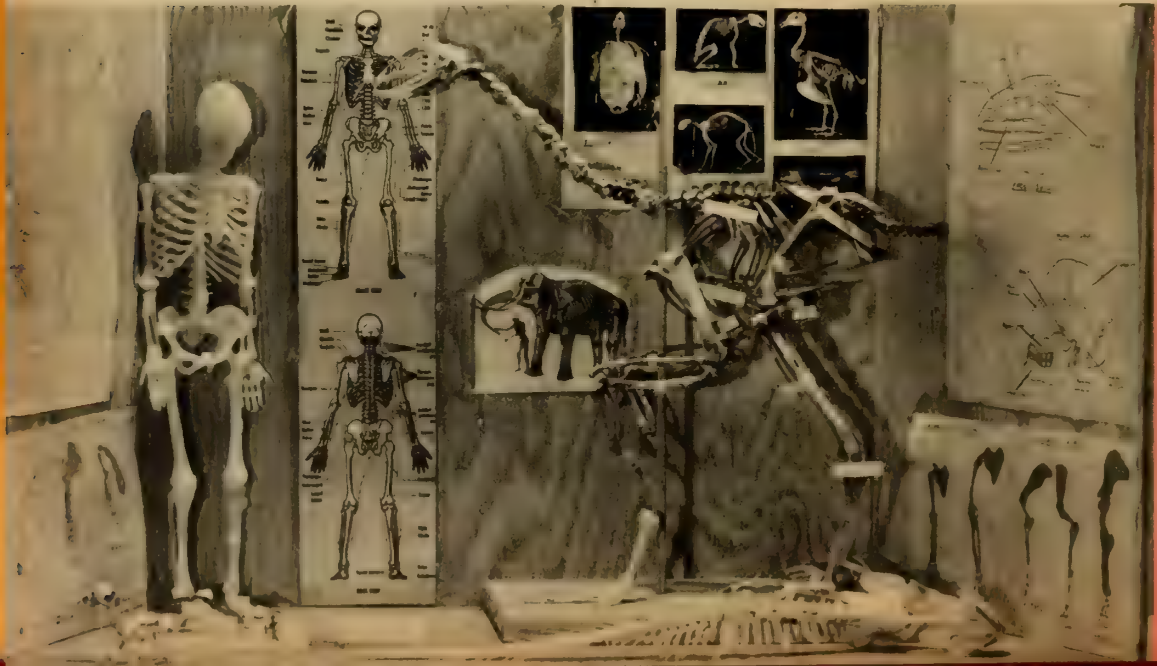


David glued the bones of a chinchilla together into this skeleton. After his cat ate one of the shoulder blades he molded a new one from plastic.

By *dissecting* (cutting apart) the animals, I have learned to recognize some of the internal organs. I've also noticed how the vertebrae next to the skull differ from the others. These vertebrae permit an animal to nod and turn its head. A skeleton can reveal a lot about an animal's way of moving, its diet, and other habits.

Making animal skeletons has been an exciting and rewarding hobby. I hope to make more animal skeletons—especially a snake skeleton—in the future ■

■ For information about putting animal skeletons together, send for the booklet, **How To Make a Chicken Skeleton,** available for $1.00 from Educational Services Incorporated, 108 Water Street, Watertown, Massachusetts 02172.



David prepared this exhibit of bones and skeletons at his school, Center Junior High in Wenham, Massachusetts.

nature and science

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BRAIN BOOSTER CONTEST WINNERS

Here are the winners of the Brain-Booster Contest that was announced in the February 7, 1966, issue of *Nature and Science*. A total of 2,176 entries were received, and the winners were selected on the basis of their answers to all six contest questions. The winner in each group was awarded his choice of a microscope with 50, 150, and 300-power lenses or a 50-power refractor telescope, provided through the courtesy of Edmund Scientific Co., Barrington, New Jersey. The runner-ups received copies of the *Bone Picture Book.*

FOURTH GRADE AND BELOW

Winner: Jerry Blackwell, Houston, Texas.
Runner-ups: Chip Huffman, Plantation, Florida; Kurt Eakle, Milwaukee, Wisconsin; Eric Ossiander, Juneau, Alaska.

FIFTH GRADE

Winner: Rick Slaughter, Harrah, Washington.
Runner-ups: Kurt Henize, Evanston, Illinois; Dianne Weiks, Seattle, Washington; Sami Tabikh, Riverside, California.

SIXTH GRADE

Winner: Mark Martin, Kennett Square, Pennsylvania.
Runner-ups: Frederick Greis, Holden, Massachusetts; Christian L. Holz, Heslett, Michigan; Wendy Yang, Chillicothe, Ohio.

SEVENTH AND EIGHTH GRADES

Winner: Anna Engell, Sarnia, Ontario.
Runner-ups: Gary Field, Danvers, Massachusetts; Robert Manthey, Wisconsin Rapids, Michigan; Martin Zalicik, Houston, Texas.

HIGH SCHOOL AND ADULTS

Winner: Peter G. Wiinikka, San Jose, California.
Runner-ups: Joseph Maier, St. Petersburg, Florida; Sister M. Fulgenta, Wausau, Wisconsin; Peter Spool, Bayside, New York.

WINNERS' ANSWERS TO THE CONTEST QUESTIONS

1. Question: *Identify Mr. Brain-Booster in a photo of four men (a poem offered some clues).*

Answer: "Zygomatic arch" gave me the clue;
Man, I think I know who is who.
Mr. Brain-Booster, with the high I.Q.,
Are you holding the cranium? If so, I've guessed *you!*

Rick Slaughter, Harrah, Washington

2. Question: *What shape would the mold shown in a photo have if it had been put into a square dish instead of a round dish to grow?*

Answer: I think the mold in the square dish would still be round. The shape of the dish does not affect the way the mold grows until it reaches the walls of the dish. *Jerry Blackwell, Houston, Texas*

3. Question: *About how many hairs do you have on your head? How did you make your guess?*

Answer: I have about 88,000 hairs on my head. I made my guess by having a friend count the number of hairs in a small space on my head. Then I measured how many of those spaces I have on my head. I multiplied the number of spaces by the number of hairs in each space. *Jerry Blackwell, Houston, Texas*

4. Question: *If soil comes from rocks, why is there so little soil on the tops of high mountains?*

Answer: The "soil" that is formed from rocks (by chemical or mechanical weathering) on, or near, the tops of high mountains is quickly removed from the high, steep places by the action of gravity, wind, rain, and running water, and is transported to lower, less steep places where it can accumulate (or be washed out to sea). *Peter G. Wiinikka, San Jose, California*

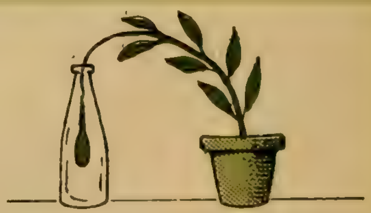
5. Question: *What is it? (a "mystery photo")*

Answer: The picture is a piece of single corrugated cardboard slit against the grain about half way and folded back from the slit.
Mark Martin, Kennett Square, Pennsylvania

6. Question: *What will happen to the weight of popcorn after popping? Why?*

Answer: The weight of the popcorn becomes less after popping. My father and I constructed a crude pair of scales and did an experiment with the popcorn. The popped popcorn was much lighter. In one of the previous Brain-Boosters I read that moisture, when heated inside the kernel, bursts the corn. I assume then that popped popcorn loses moisture and this is why the change in weight takes place. *Anna Engell, Sarnia, Ontario*

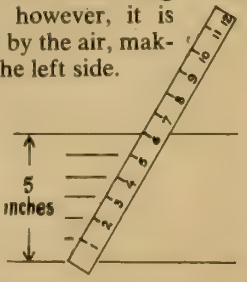
ANSWERS TO BRAIN-BOOSTERS on page 10



What Will Happen If . . . ? Although carbon dioxide is heavier than air, the weight of the materials inside the bag is unchanged. Since the inflated bag takes up more space, however, it is buoyed up a little more by the air, making the scale go up on the left side.

Mystery Photo: The live cucumber was put into the bottle when it was small, and left there until it was fully grown.

Fun with Numbers and Shapes: Here is how to divide the five-inch space into six equal parts.



Can You Do It? You can put a quarter through a dime-sized hole by folding the paper in half across the hole, and pushing the quarter through.

For Science Experts Only: Most of the snow is traveling with the current of air that passes up over the windshield.

Using This Issue . . .

(continued from page 2T)

References

- "How Insects Escape Their Enemies," *N&S*, April 17, 1964.
- *The Insects* (1962) and *Ecology* (1963), LIFE Nature Library, Time, Inc., New York, $3.95 each, both have texts and photos that illustrate animal camouflage.
- *Animal Camouflage,* by Dorothy Shuttlesworth, to be published in the early fall, 1966, by Natural History Press, Garden City, N.Y.

PAGE 11 Viruses

The question of whether or not viruses are "alive" may spark a lively discussion among your pupils. The answer depends on what is meant by the word "alive," and there is some difference of opinion among scientists on the subject.

You might have your pupils try to think of ways to distinguish between "living" and "non-living" things. Some of them will suggest the life processes mentioned in the article – reproduction, heredity, and growth. Others may suggest such processes as respiration, feeding and excretion, movement, and irritability.

But only two of these processes are characteristic of *all* living things and found in no non-living things. These are the ability to reproduce and to pass on their characteristics to their offspring (heredity).

Some of your pupils may suggest that living things are made of different materials than non-living things. Point out (or have them find in an encyclopedia) that the elements that make up living things (carbon, hydrogen, oxygen, nitrogen, phosphorous, iron, etc.) also make up non-living things.

Someone may suggest that the atoms of these elements are arranged differently in the molecules that make up living matter than in molecules that make up non-living matter. It is true that the molecules that make up living matter consist of more atoms arranged in more complicated ways than the molecules that make up non-living matter. In fact, nucleoprotein molecules and nucleic acid molecules are among the largest and most complex molecules we know of.

A living cell is composed of molecules such as these, organized in a system that is capable of using energy from outside sources (food, air, sunlight) to maintain itself and to produce more systems (cells) organized just like it.

Few non-living things, on the other hand, are capable of using energy to maintain themselves (a solar battery, for example), and none reproduce themselves.

Many scientists believe that it is meaningful and useful to consider the cell as the basic unit of life. Others believe that some viruses, at least, meet the requirements of self-maintenance and reproduction well enough to be considered "alive." But most scientists agree that the boundary between "living" and "non-living" is becoming more and more difficult to define.

◀N&S REVIEWS▶

Recent Natural History Books for Your Pupils

by Barbara Neill

Birds and Their Beaks, by Olive L. Earle (William Morrow and Co., 64 pp. $2.75). Here is a potpourri of birds, from "Albatross, Wandering" to "Woodpecker, Hairy." Each bird is discussed briefly and illustrated with the author's black and white drawings. No attempt has been made to organize the material. Perhaps the author was overwhelmed by the diversity, but it would seem that a grouping of any sort–shape of bill, bird family, bill uses–would be preferable to an alphabetical listing. Nevertheless, this is a readable and informative book for upper elementary grade children.

Animals as Parents, by Millicent E. Selsam (William Morrow and Co., 96 pp. $2.95). Mrs. Selsam's books are consistently accurate and written in a clear, readable style. This time she is writing about animals and their young. She has wisely chosen animals whose behavior scientists have studied most intensely. The result is an authoritative book for children which emphasizes the scientific approach.

A number of recent experiments are described, some resulting in as many questions as answers. The famous experiments with the baby Rhesus monkeys and their artificial mothers, the experiments of Dr. Konrad Lorenz with his imprinted ducklings, and the recent discoveries of George B. Schaller about gorillas are all in this book. This is a fascinating study which should stimulate children to observe and to read more on their own. There is a bibliography.

All About Elephants, by Carl Burger (Random House, 132 pp. $1.95) and **Elephants, Last of the Land Giants,** by Anthony Ravielli (Parent's Magazine Press, 48 pp. $4.04), are both illustrated by the authors. *All About Elephants* also contains a great many photographs, some of them remarkable. There are chapters on the capture of wild elephants and the prehistoric ancestors of modern elephants. Three short, fictional biographies of a wild elephant, a working elephant, and a circus elephant help show how these animals live and adapt to different conditions.

The last chapter stresses the dilemma of African elephants today. Since they rarely breed in captivity, their survival depends upon enough food and space in the wild, yet this space will probably be needed by the expanding human population. This should provoke some serious thought in the book's readers.

The text of *Elephants, the last of the land giants,* is comparatively brief. The book is distinguished by its abundance of excellent, full-color illustrations.

Another book to be noted for its truly beautiful and accurate illustrations is **Turtles**, one of the Beginning Knowledge Books of Rutledge Books, Inc. (30 pp. $1.95).

Barbara Neill is a Senior Instructor in the Education Department of The American Museum of Natural History in New York City.

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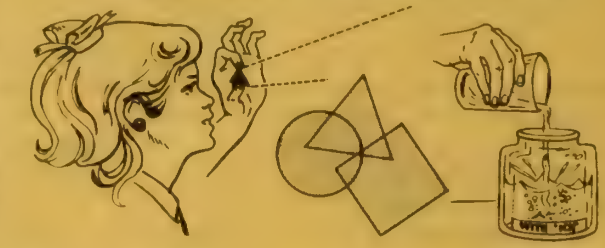

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nature and science

VOL. 3 NO. 17 / JUNE 27, 1966

SPECIAL ISSUE

EXPLORING A FOREST

nature and science VOL. 3 NO. 17 / JUNE 27, 1966

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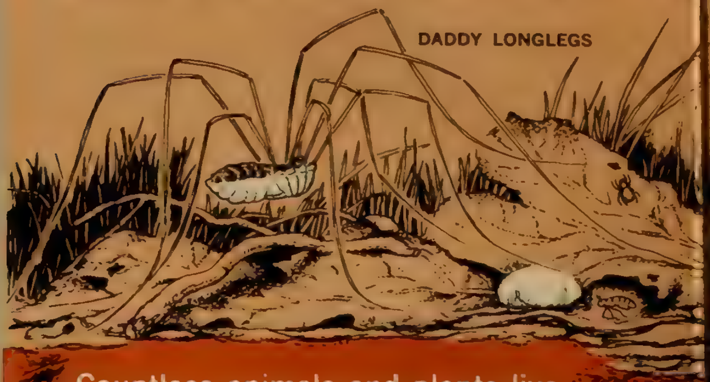
EXPLORIN



Countless animals and plants live in the few inches of litter under forest trees With a few simple tools, you can investigate this small but fascinating world.

■ The forest floor is a spongy carpet. Except for a scurr ing chipmunk and some wildflowers, it may look still a dead. Just the opposite is true. There is more life a activity here than in any other part of the forest. Here where the forest blends with the earth. Here is the tr nursery–where forest life starts. And here is where l in the forest ends.

The floor of a forest is a fascinating place to explo This article tells about some things you can look for wh you visit a woods, either in the country or in a city par Let's begin with the beginning–a tree seed.

Once a tree seed is mature, it falls to the forest flo If conditions are right, the seed will sprout and grow in a tree. Most seeds are not ready to grow when they fi reach the forest floor. Some have tough, waterproof coa ings. It takes almost a year for moisture to work throu these seed coats. Other seeds must be chilled for a tin before they begin to grow. Certain seeds with hard, pr tective coats begin to grow after they have gone throug the digestive systems of birds or mammals.

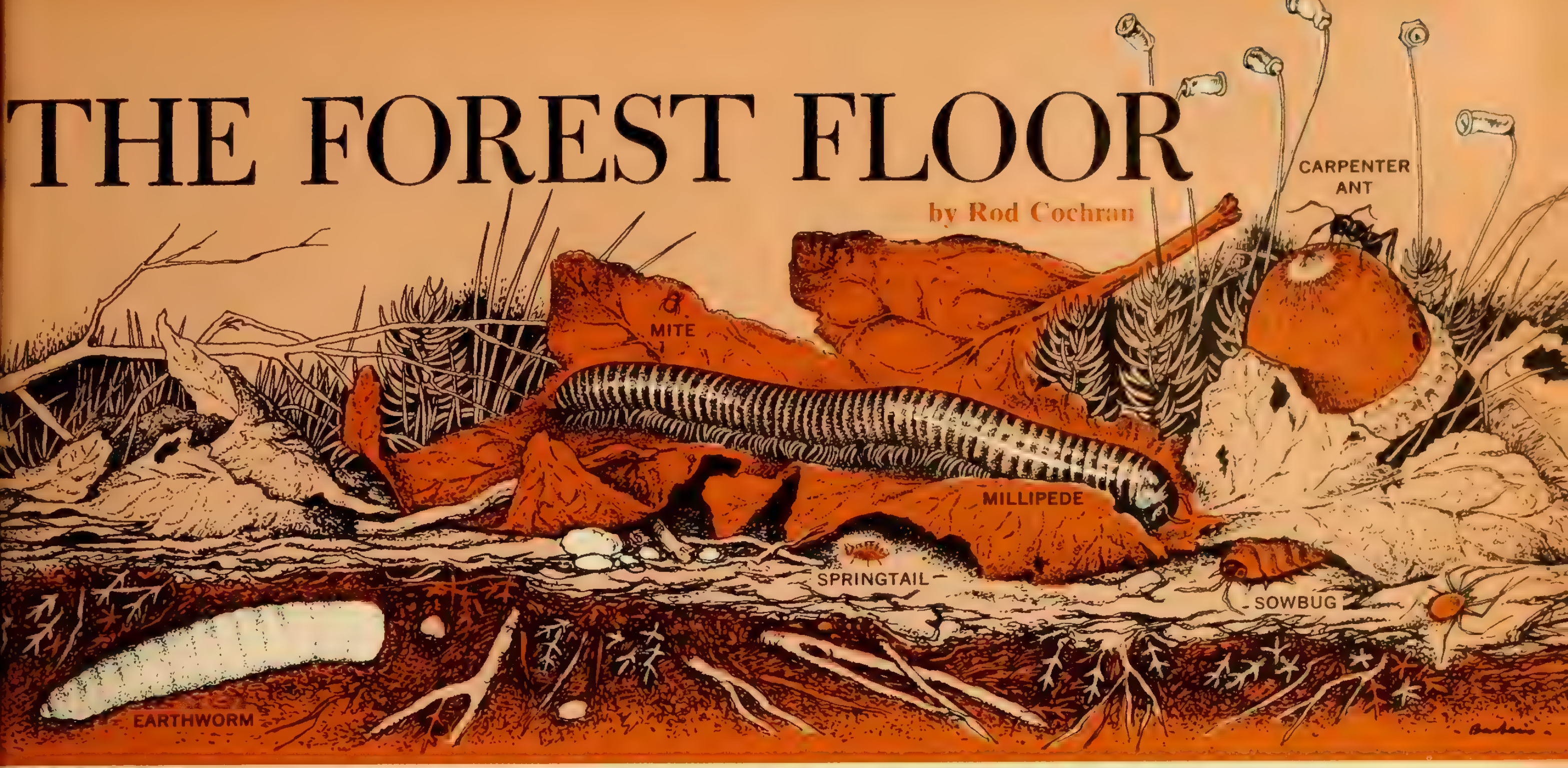
From their nursery on the forest floor, seeds becom sprouts, then seedlings, saplings, and finally trees. But on a few of the thousands of seeds that fall ever become tree Many seeds are eaten by mice, insects, and other animal The seedlings are also eaten by animals. And each youn tree competes with other plants for sunlight, water, an minerals from the soil *(see page 16).*

The Forest Wastebasket

Foresters estimate that about 4,000 pounds of plant an animal material fall upon an acre of forest floor each yea

THE FOREST FLOOR

by Rod Cochran



Dead or windblown trees make up only part of this debris. Leaves, tree flowers, fruits, seeds, twigs, plants such as wildflowers, and dead animals are all included in the total. Everything that lives in the forest eventually becomes a part of the litter.

Yet the forest does not become choked in its wastes. Each leaf, twig, or tree that falls is chemically broken down by many kinds of plants and animals. This is why there is more life and activity in the litter than anyplace else in the forest. Stick your hands into a soft part of the forest floor. In one pound of this material you may hold up to 30 billion soil bacteria—the tiny living things that break down some of the plant and animal wastes.

There are also many soil animals in the forest. The ones that are most abundant are too small to be seen without a microscope, but there are also many you can see. A few years ago, scientists dug up a square foot of forest floor, one inch deep, in a New York forest. They could see 1,356 living animals, mostly insects and mites.

You already know of some bigger animals, such as toads and chipmunks, that live on and under the forest floor. But dozens of other kinds of animals are not as noticeable. Shrews dart through the litter searching for food. Deer mice make their homes in hollow logs. These small mammals are usually active at night and are seldom seen. *(For information on how to catch and study small mammals, see page 10.)*

Layers of Life and Death

Most of the fascinating world of the forest floor remains hidden from view. To explore it takes a little digging. Use a small trowel to dig through the litter. Have some pill bottles or other small containers in which to store specimens for later study. To collect microscopic animals, take home a couple of handfuls of the forest floor in a plastic bag. Keep it as near to its natural condition as possible—moist but not soaked in water. Then take tiny bits of decayed leaves, put them on a glass slide, add a drop of water, and look at them with a microscope *(see "Make*

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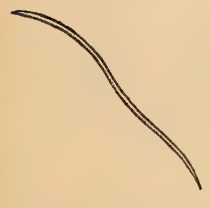
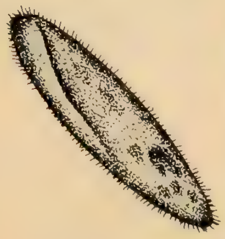
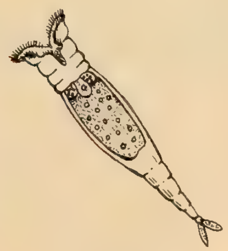


ROUNDWORM
(magnified 30 times)



PARAMECIUM
(magnified 180 times)



ROTIFER
(magnified 100 times)

In the water-filled spaces of leaf fragments, you'll find many microscopic animals like the ones drawn at the left.

Your Own Microscope," N&S, *Dec. 6, 1965).* The diagrams on page 3 show some of the tiny organisms you may see.

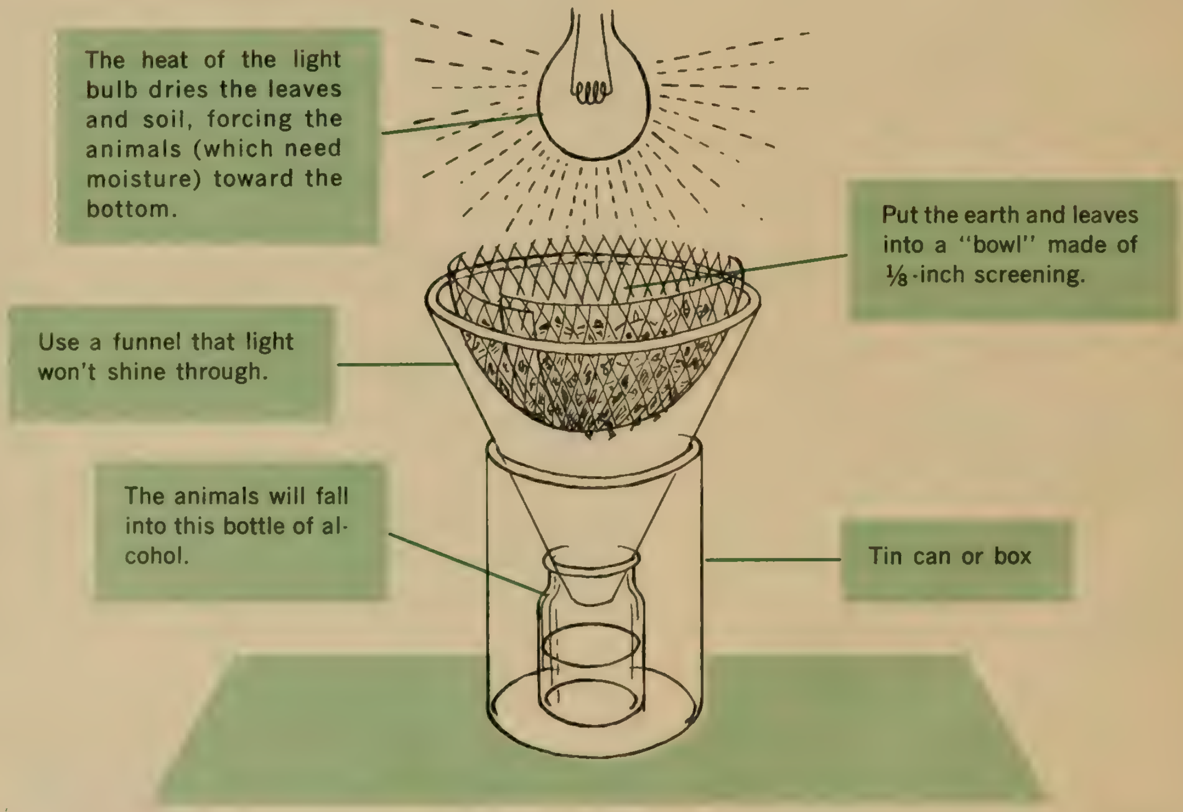
After scratching away the top layer (last year's leaves and twigs), you will find parts of leaves or leaf skeletons. These will be fragile and fairly well decayed. The first wave of the woodland "waste disposal system" has already been at work. This is carried out mostly by bacteria and fungi *(see page 5),* which are most active during warm weather. They do not need sunlight, as most other plants do, and can "work" around the clock. As a leaf or twig is broken into ever finer pieces, more of its surface is exposed to decay. As you dig deeper, you probably won't be able to tell where decayed leaves end and where soil begins. The leaves and other material have decayed into rich, dark *humus*—the top layer of soil.

You will find many kinds of animals in the humus and in the layers of rotting leaves. Take along a hand lens (small magnifying glass) to get a close look at them. Mites and springtails *(see diagram on pages 2 and 3)* will be most common. You should be able to find dozens or even hundreds of them. Springtails are well named for they turn backflips when exposed to the air.

You may also find millipedes, earthworms, rove beetles, sowbugs, mole crickets, daddy longlegs, spiders, and many others. About 95 per cent of all insects spend one or more stages of their lives in the soil. When you add these to all the other animals that crawl and burrow in the soil, you can understand why the forest floor feels like a soft carpet when you walk on it. It is punched full of holes. There are

INVESTIGATION

Collect a square foot of forest floor, one inch deep, put it in a plastic bag and take it home. Go through it and try to find and identify as many animals as you can. Then make a "Berlese separator" to catch the animals you missed. The diagram below shows how to make one and the labels tell how it works.


The heat of the light bulb dries the leaves and soil, forcing the animals (which need moisture) toward the bottom.
Put the earth and leaves into a "bowl" made of ⅛-inch screening.
Use a funnel that light won't shine through.
The animals will fall into this bottle of alcohol.
Tin can or box

After a few days, take out the alcohol bottle and pour its contents into a white saucer. You will probably need a magnifying glass to identify your catch. What is the total number of animals you found in your small chunk of forest floor? Do you think you would find different numbers and kinds of animals in other parts of a forest? In other seasons? Try to find out. The book list will help you identify the animals you find.

tunnels, channels, burrows, passageways—millions and millions of them.

With each bit of digging in the litter, the rich, life-giving humus is mixed with soil particles. This mixing and digging also helps give the forest floor its blotter-like ability to hold water. The holes and tunnels serve as miniature water reservoirs, holding the rain or melted snow until it has time to soak deep into the soil. The leafy litter and humus are spongy, and hold still more water. By soaking up rainfall, the forest floor keeps the water from wearing away the soil and helps prevent floods.

The Worms' Turn

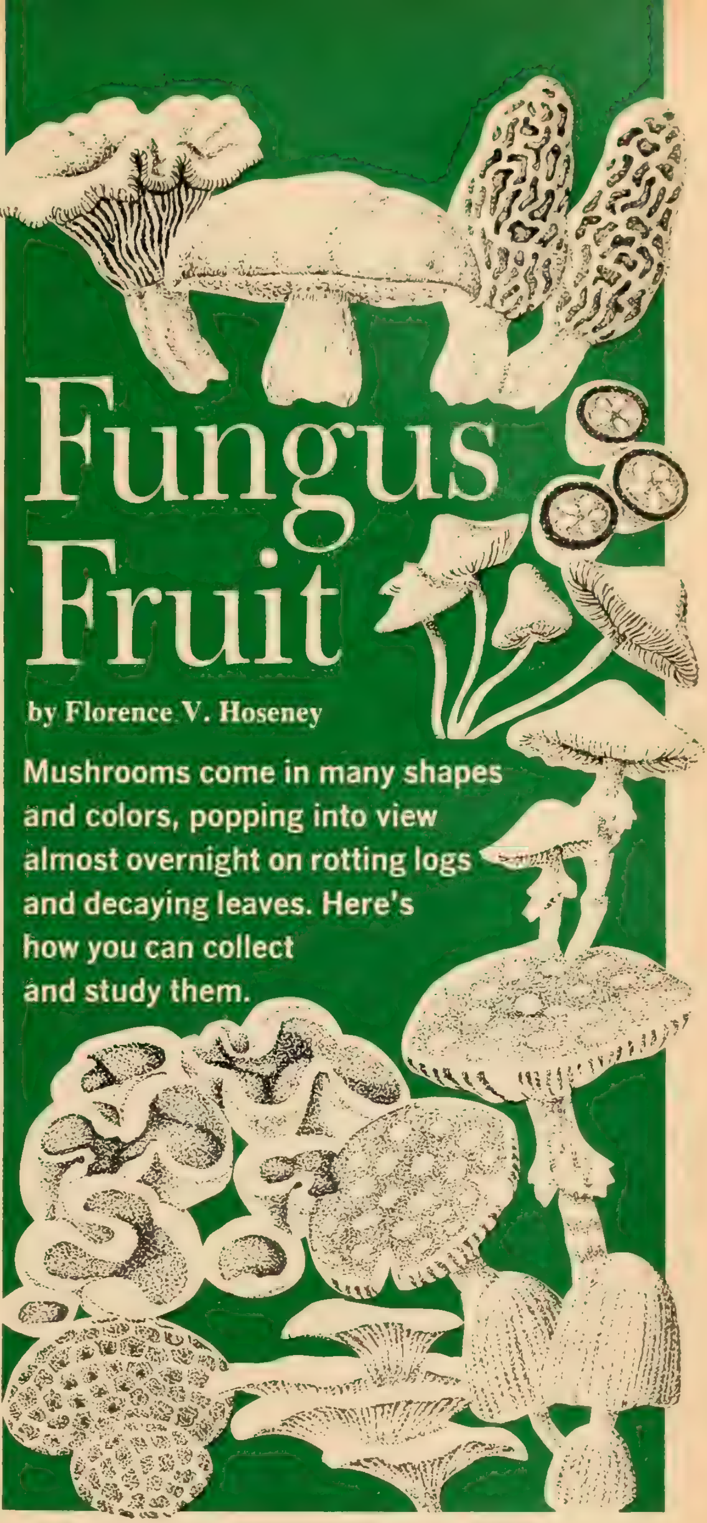
As you explore the forest floor, you will probably find some earthworms. They are especially valuable animals in the forest. When earthworms take leaf fragments into their slit-like "mouths," bits of soil from the worms' burrows are taken in with the leaves. As the material passes through the worms' bodies, it is broken down and ground up until it is like a paste. Finally the remains of the digested leaves are deposited on the surface as tiny pellets, called *castings.* You may have seen these little mounds in gardens and lawns.

In their simple ways, earthworms are important forest animals. Through their burrows, air and water enter the forest soils. Through their feeding, leaves and other plant materials are digested and mixed with the soil. Then the minerals and other "building blocks" of the leaves can be used again—perhaps by being taken up by the roots of a tree or wildflower.

Earthworms can't do the whole job by themselves. They cannot digest wood, for instance. Also oak leaves and pine needles apparently have so much acid in them that earthworms cannot digest them. Earthworms are not abundant under oak and pine trees.

It takes the combined activity of earthworms, insects, mites, fungi, bacteria, and many other plants and animals to keep the forest floor "factory" working. When you get down on your knees and study the forest floor, you will see how it all fits together. There will be seeds, tiny plants, and countless hidden animals. Waste products of the forest will be present, slowly being changed to be used again. It is a silent world of death and rebirth, and a fascinating world to explore ■

■ These books will help you explore the forest floor and forests in general: **The Life of the Forest,** by Jack McCormick, McGraw-Hill Book Company, New York, 1966, $3.95; **The Forest,** by Peter Farb, LIFE Nature Library, Time, Inc., New York, 1963, $3.95. To identify animals of the forest floor, see: **Field Book of Insects,** by Frank E. Lutz, G. P. Putnam's Sons, New York, 1935, $3.95; and **Fieldbook of Natural History,** by E. L. Palmer, McGraw-Hill Book Company, New York, 1949, $11.95.



Fungus Fruit

by Florence V. Hoseney

Mushrooms come in many shapes and colors, popping into view almost overnight on rotting logs and decaying leaves. Here's how you can collect and study them.

■ This summer or early fall, take a walk through a woods two or three days after a soaking rain. Look for the many kinds of mushrooms that have sprung from decaying logs or the forest floor. You will be amazed at their different colors and shapes. There are over a thousand kinds *(species)* of mushrooms in North America. They all belong to the group of plants called *fungi.*

Unlike wild flowers, colonies of mushrooms are not destroyed by picking. You may gather all you want. This is

(Continued on the next page)

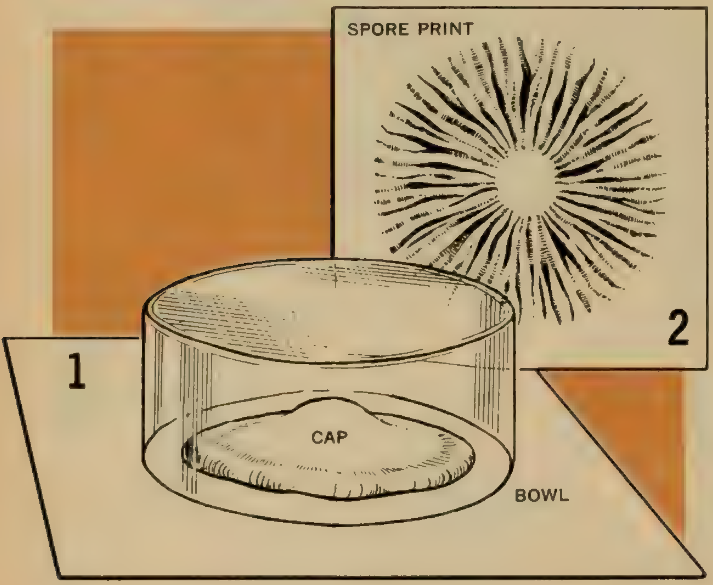
Fungus Fruit (continued)

because it is impossible to remove the *mycelium,* or network of many tiny threads from which mushrooms grow. The mycelium grows underground and may extend 10 feet or more from the mushrooms. As long as the mycelium finds food in rotting wood or leaves, it will continue to grow and produce more mushrooms. (The mushrooms are the fruit of the fungus plant. They produce the spores from which new fungi grow.)

MAKING A SPORE PRINT

1. Put the mushroom's cap, bottom down, on a sheet of white paper. Cover the cap with a glass bowl and leave it undisturbed for several hours.

2. The tiny spores fall on the paper and stick, forming a beautiful and colorful pattern. The color of the spores is a clue to the identification of the mushroom.



Unfortunately, though mushrooms grow very rapidly, they break down even more quickly. They may shrivel away, or be devoured by insects, or simply decay into a slimy blob.

One way to become better acquainted with these plants is to collect and preserve them for future study. For gathering the mushrooms, all you need is a basket, a small gardener's trowel or a dull knife, some waxed paper or plastic bags, and a pencil and pad of paper for taking notes.

Collecting and Drying

Use the trowel or knife to lift the mushrooms from the soil so their lower parts won't break off. Then put each mushroom or group of mushrooms in a plastic bag, or wrap them in waxed paper, twisting the ends of the paper tightly to keep the mushrooms moist and clean. Take notes on each group of specimens. Note when and where you found them, their color when fresh, and their odor. Later, you should put this information on labels for the different specimens.

You may also want to make "spore prints" from the mushrooms. The diagrams on this page show how. Spore prints will help you identify the mushrooms you find.

To dry your mushrooms, get some *silica gel* crystals from the houseware department of a department store, or from a hardware store. (Silica gel crystals soak up moisture and are used to dry damp places, like closets. The coarse 14-20 mesh size is fine for sticky or big fungi. The fine 28-200 mesh size is best for fragile or small fungi.) The crystals can be used over and over again.

You can dry the mushrooms in plastic containers or large coffee cans with air-tight lids. First put a layer of silica gel crystals on the bottom of the container. Then arrange some mushrooms on it. Be sure that the specimens do not touch each other. Pour more crystals around and over the mushrooms. Then cover the can tightly and let it stand until the specimens are crisp and dry—usually after a day or two. Pour off the crystals carefully. Pick out the specimens with a pair of tweezers and place them (with their labels) in boxes for storage. Use a soft brush to remove any crystals still clinging to the mushrooms. Finally, put some naphthalene flakes or mothballs in the boxes to repel insects that might damage your specimens.

Some Mushroom Mysteries

Collecting mushrooms is a fascinating hobby. You can quickly learn to identify groups of mushrooms by using a field guide *(see book list).* Later you'll be able to recognize individual species. You may find some rare ones. By the way, it takes careful study to tell edible mushrooms from poisonous kinds. *Never eat any mushrooms you find unless your identification has been checked by an expert.*

This summer, see what you can discover about the mushrooms that grow in your area. How many different species are there? Do some species grow only on rotten wood? What kinds of animals eat mushrooms?

Mushrooms grow very quickly. Do you think you could figure out a way to discover just how fast they grow? ■

■ Look in your library or bookstore for these books on the identification and lives of mushrooms: **The Mushroom Hunter's Field Guide,** by Alexander Smith, University of Michigan Press, Ann Arbor, Michigan, 1963, $6.95 (an advanced book, but well-illustrated with photographs); **The How and Why Wonder Book of Mushrooms, Ferns and Mosses,** by Amy E. Jensen, Grosset & Dunlap, New York, 1965, $1 (paper); **The Story of Mosses, Ferns and Mushrooms,** by Dorothy Sterling, Doubleday, Inc., New York, 1955, $2.75.

WEATHER IN THE WOODS

■ Some sunny day this summer, take a few minutes and walk from a hot "desert" to a cool "mountain." You will find the desert-like conditions at the surface of a sidewalk, driveway, or parking lot. To find cool "mountain" weather, simply go to the nearest woods.

The trees that make up a forest have a remarkable effect on its *climate* (the weather an area has over the years). For example, you will find that most of the sunlight that beats down on a sidewalk never reaches the ground in a forest.

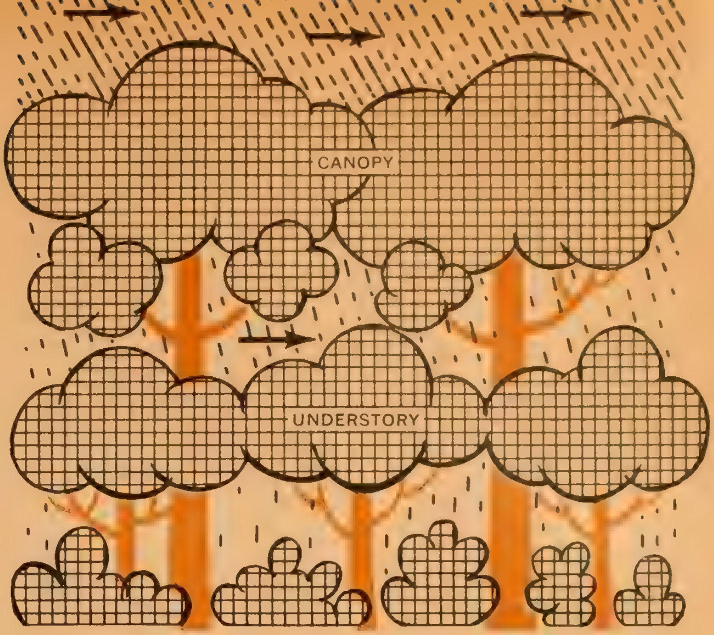
One sunny July afternoon, a forester measured the amount of sunlight at different levels in a New Jersey woods. He found that some sunlight was reflected from the tops of the trees. More than half of the sunlight was soaked up by the leaves of the tree tops (*canopy*). Only about one-fifteenth of the sunlight reached the small trees (the *understory*). In some parts of the woods, less than one-hundredth of the sunlight reached the forest floor.

The forester discovered that the amount of sunlight at different levels in the forest also affects the temperature of the air. At the top of the canopy, the temperature was 96° Fahrenheit. At the forest floor it was 71°.

An Umbrella of Leaves

Trees have other effects on a forest's weather. Strong winds that whip across open fields are slowed to a light breeze inside a forest. Rain beats down on open land, loosening soil and sometimes washing it away. In a woods, the rain from a brief shower may not even reach the soil. Many drops cling to leaves, twigs, and bark. Some of these drops drip gently to the understory and finally to the forest floor (*see diagram*). A few drops soak into the rotting leaves. A lot of rain must fall before the water begins to reach the soil beneath the spongy, decaying leaves.

The investigations tell how you can study some of the ways the trees of a forest affect its weather from day to day and from season to season.—LAURENCE PRINGLE



When a windy rainstorm rages at the top of a forest, the weather is different near the forest floor. The wind (shown by arrows) is slowed by leaves and branches. Rain clings to leaves and drips gently to the ground.

INVESTIGATIONS

- Make two rain gages to measure the amount of rain that falls in a storm. You'll find directions in the article "Make Your Own Weather Station" (N&S, *April 4, 1966*). The article also tells how to make a device for measuring the moisture in the air. With it, you can compare the air's moisture inside and outside of a forest.

  When you have made the two rain gages, set one on the ground in an open field and the other inside a woods. After a rainstorm, measure the amount of rain that fell in each. How much rain was kept from reaching the gage by the shrubs and trees of the forest? Measure the rainfall of several storms, including light showers. Can you figure out how much rain must fall on a forest before water begins to collect in the forest rain gage?

- This article mentions some differences in temperature in a woods on a sunny day. Would you expect the same conditions on a cloudy day? To find out, get at least four inexpensive thermometers. Make sure that they are all working correctly (set them in one place for a while and see if they all have the same reading). Then set the thermometers in different places in and near a woods. Put one on the forest floor. Put another underneath the layers of rotten leaves. Tie or tape another to a dead sapling (at least 10 feet long) and lean the sapling against a tree (this will give you the temperature of the air at that level). Put the fourth thermometer on the ground in an open field near the woods.

  Take notes on the temperatures at these different places on a sunny day. Then see what the temperatures are on a cloudy day. Is there a bigger difference in temperatures at the various places on a sunny day or on a cloudy day?

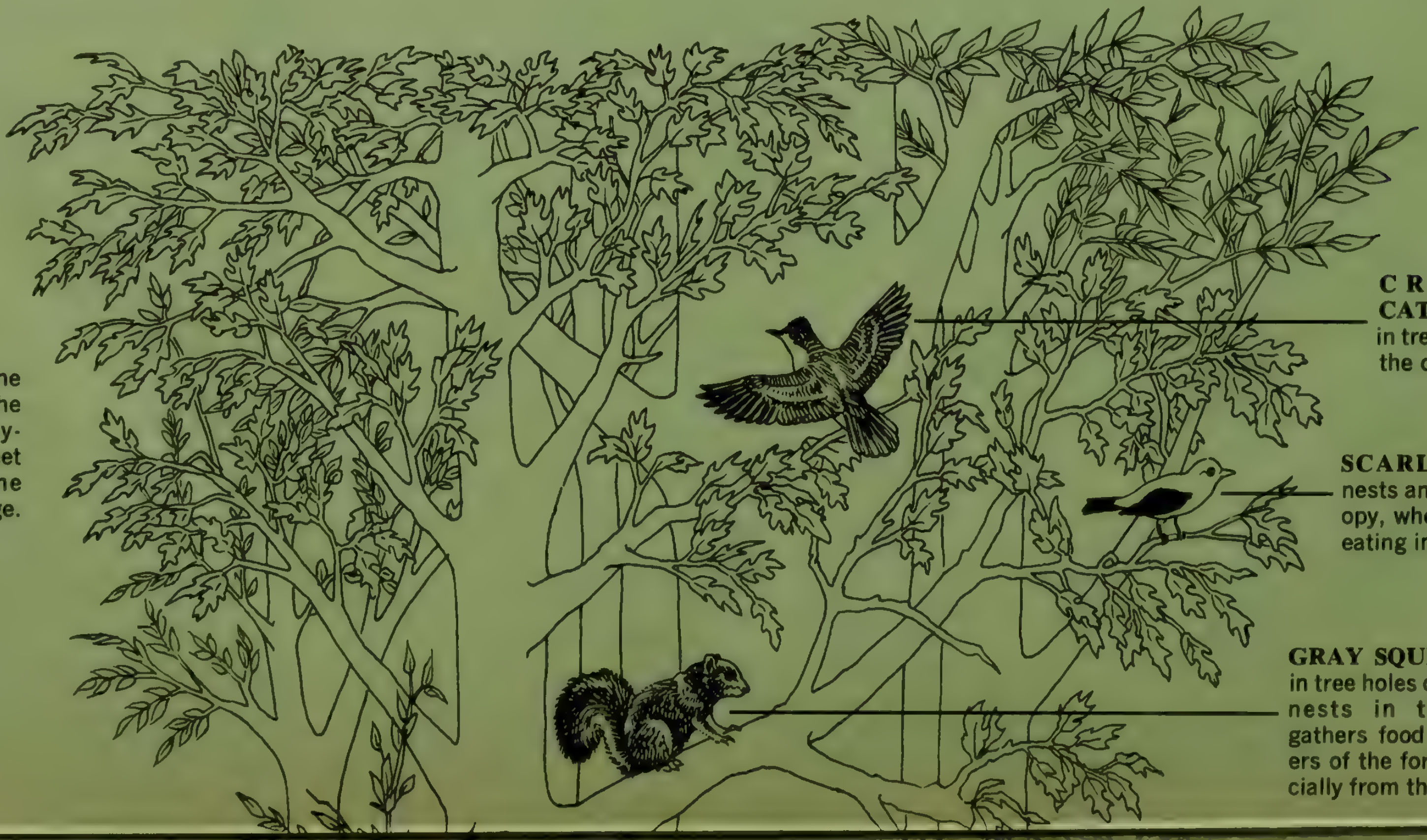
layers of forest life

■ At first glance, a forest may seem like a jumble of bushes and trees. Look around in a woods though, and you will begin to see a pattern—the plants are arranged in layers (*see drawing*).

High above your head, the canopy is warmer, sunnier, and windier than the layers below it. At your feet, the herb layer is dim and cool, with moist, "muggy" air. In ways like these, each layer is a little different from the others. Because of these differences, each layer is the home of different kinds of animals.

Some kinds of animals are born, live, and die in just one layer of the forest. Some may catch their food in one layer and make their nest or den in another. Others, such as squirrels and blue jays, may be found in all of the different layers. You'll find the greatest variety of life in the herb and forest floor layers. Most forest insects, for example, spend part of their lives in or below the forest floor.

This Wall Chart shows some of the animals you might find in the layers of an oak-hickory forest (a common kind of forest in central and eastern United States). No matter what kind of forest grows in your area, watch for the different layers of life on your next walk in the woods ■



CANOPY
The leafy crowns of the tallest trees make up the canopy. It may be anywhere from 25 to 250 feet high depending on the kind of trees and their age.

CRESTED FLYCATCHER nests in holes in trees; feeds on insects in the canopy.

SCARLET TANAGER nests and feeds in the canopy, where it catches leaf-eating insects.

GRAY SQUIRREL nests in tree holes or builds leafy nests in the canopy; gathers food from all layers of the forest but especially from the forest floor.

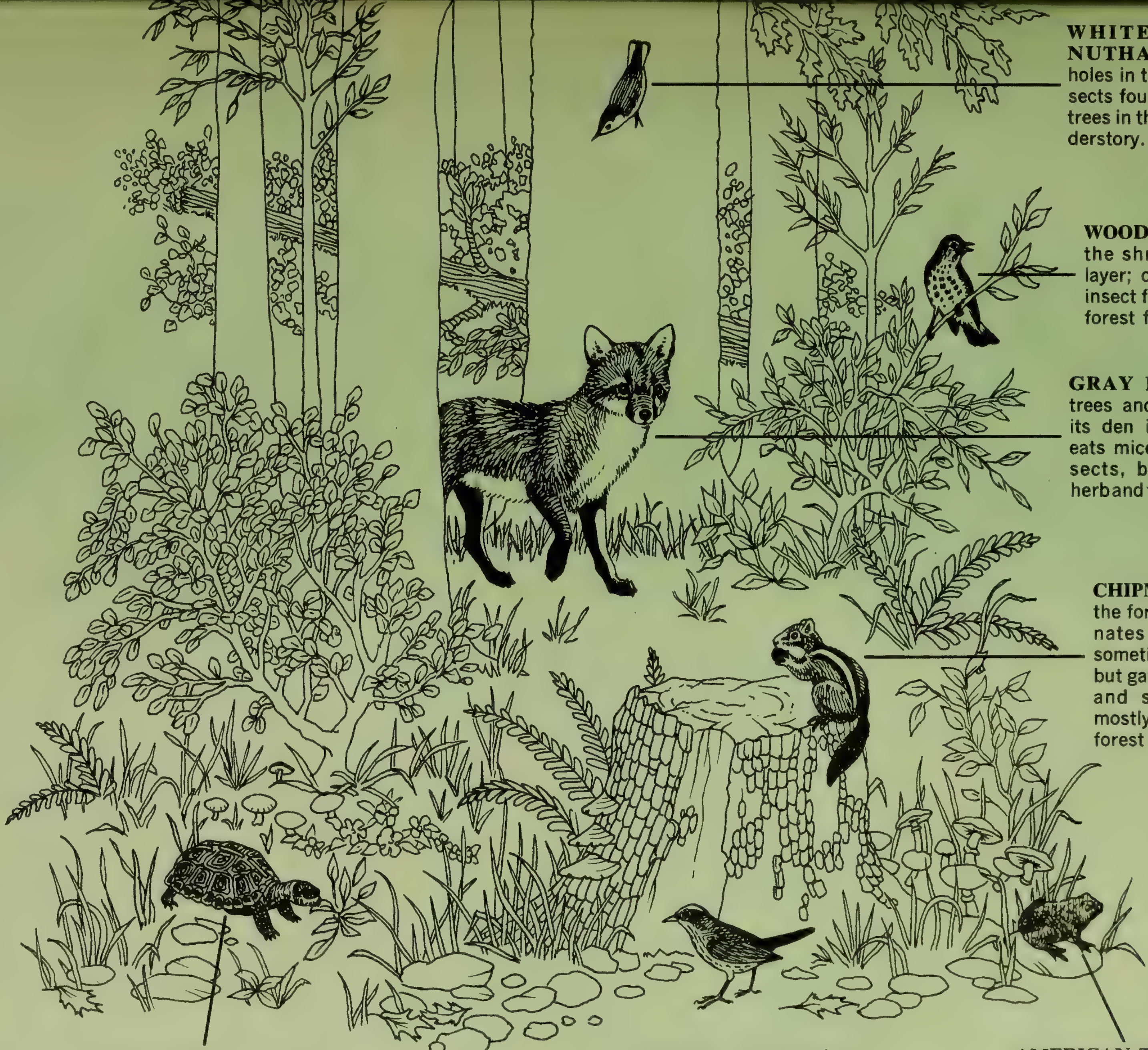
UNDERSTORY

grow to be only about 20 feet high.

SHRUB LAYER
In some kinds of forests, especially dense evergreen forests, there may be so little light that no shrubs or bushes can grow.

HERB LAYER
The herb layer is made up of wildflowers, ferns, mushrooms, mosses, and other small plants.

FOREST FLOOR
On the forest floor, leaves and other plant and animal matter slowly decay and become soil.



WHITE-BREASTED NUTHATCH nests in holes in trees; feeds on insects found on the bark of trees in the canopy and understory.

WOOD THRUSH nests in the shrub or understory layer; catches most of its insect food in the herb and forest floor layers.

GRAY FOX can climb trees and sometimes has its den in a hollow tree; eats mice, chipmunks, insects, berries from the herb and forest floor layers.

CHIPMUNK nests below the forest floor (and hibernates there in winter); sometimes climbs trees, but gathers seeds, berries, and small animal food mostly from the herb and forest floor layers.

BOX TURTLE eats insects, earthworms, and berries from the herb and forest floor layers, and digs underground in winter.

OVENBIRD nests on the forest floor; feeds there and in the herb layer.

AMERICAN TOAD lives on the forest floor, catching insects and snails, burrowing underground to hibernate in winter.

Face to Face with Wild Mice

by Christopher R. Hale

We hardly ever see the many small mammals that lurk in nearby woods and fields. With some simple homemade traps, you can catch them alive and study them.

■ Who lives in your garden, in the empty lot down the street, in the nearby forest or park? You have probably seen birds and squirrels in these places. You may have even noticed various insects, earthworms, and an occasional toad or snake. But how often do you see a small mammal—a mouse, mole, or shrew?

Maybe there aren't any small mammals living near you. Or maybe you just haven't been able to see them.

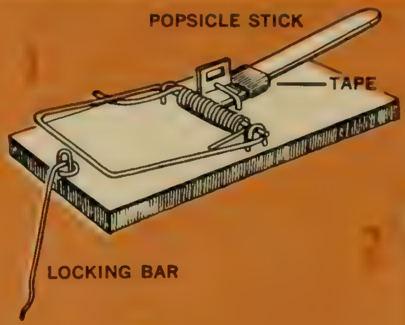
A good way to find out if there are any small mammals living nearby is to do some "live trapping." "Live traps" are traps especially designed to catch small mammals without hurting them. They are often used by biologists who want to find out what kinds of mammals and how many mammals live in a certain place.

You can buy live traps from some hardware stores. It is possible, however, for you to make your own inexpensive live traps for catching small mammals *(see drawings)*. Most of the materials you'll need are probably lying around your house right now.

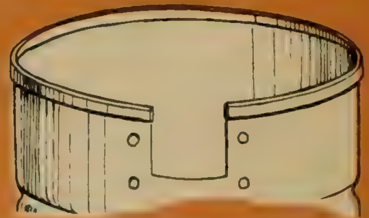
Baiting and Setting

When you have made a few traps, decide what to use for bait. Many biologists use peanut butter. It is a messy business, but I mix dry oatmeal with peanut butter. Use lots of oatmeal and only just enough peanut butter so that it all sticks together in little balls. Stick the bait on

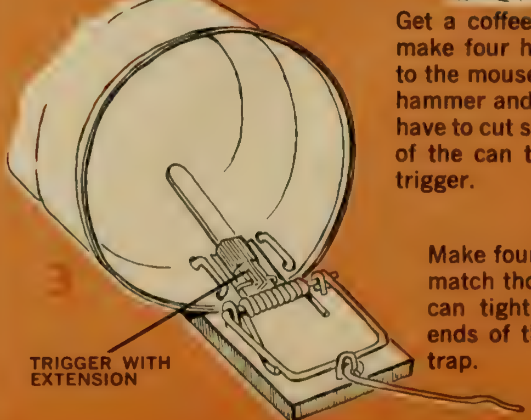
How to make a "Live Trap"



Tape an extension (about 1½ or 2 inches long) onto the trigger of a mouse trap. You might use a popsicle stick.



Get a coffee can or large juice can and make four holes in it for wiring the can to the mouse trap. Make the holes with a hammer and nail, or drill them. You may have to cut some metal away from the rim of the can to allow room for the trap's trigger.



Make four holes in the wooden trap to match those in the can. Then wire the can tightly to the trap, twisting the ends of the wires together under the trap.

the end of the trigger just before setting the trap. Sometimes a little water makes the bait stick on better.

Set your traps in places where mice and other small mammals might live. For example, look for runways or tunnels in tall grass at the edge of fields, in marshy places, or under rotten leaves. Also watch for small holes in the ground. Alongside flat rocks and fallen trees in the woods are other good places to set traps.

When you place your trap, be sure that there is nothing to get in the way of the door when it closes. Set your trap without baiting it. Then tap it to see how easily it goes off. You may need to experiment with the setting to get the best sensitivity. Then bait and set. It is sometimes helpful to partly cover the trap with grass or leaves; this is to keep dogs, birds, and younger brothers and sisters from discovering the trap.

CAUTION!

Do not leave your trap set overnight in cold weather. You might freeze your catch. Traps should not be left set anytime unless you will be able to check them within 4 to 8 hours. Some small mammals are not able to live longer than this without food.

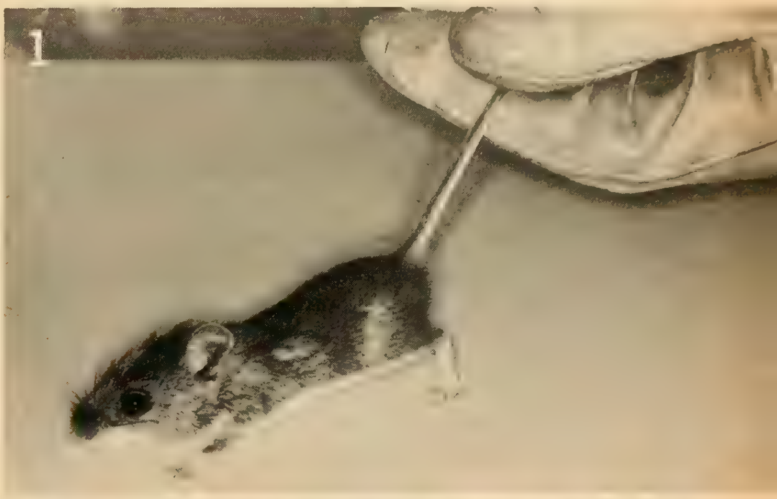
When You Catch Something

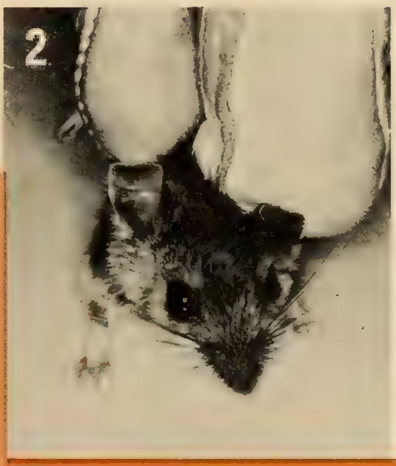
Naturally, you should expect that the mammals you catch will be small enough to fit in your trap. Mammals of this size include deer mice, meadow mice (voles), jumping mice, shrews, chipmunks, rats, and, perhaps, moles. Some books that will help you to identify your catch are listed at the end of the article. Positive identification is not as easy as it seems.

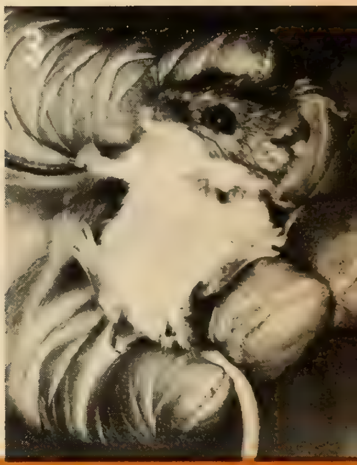
Handling your catch can be a little difficult. I have lost more animals in my house than I have caught in it, so it is best to work outdoors. *You should think of the mice and other mammals you catch as dangerous beasts.* They can bite, though some species are much less likely to bite than others.

Suppose you have caught a deer mouse. The photos on this page show how to handle it. *Be sure to wear gloves.*

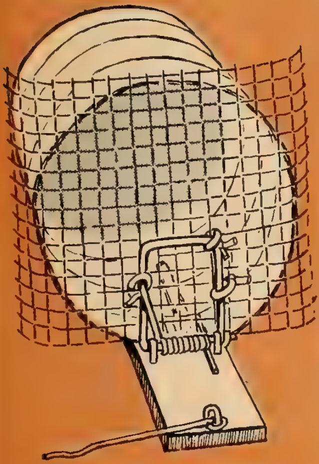
(Continued on the next page)

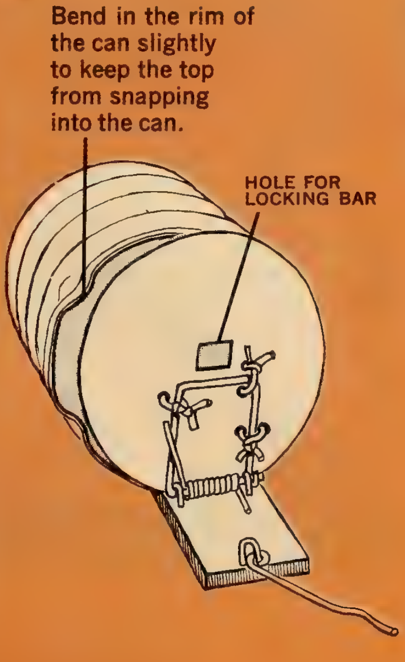






When you catch a mouse, first empty it from the trap into a big paper bag, a box, or a wastebasket. Then, wearing leather gloves, catch and pick up the animal by its tail. Lower the mouse gently onto a flat surface so that it can stand on all four feet (*photo 1*). While still holding the tail, use your free hand to take a firm hold on the loose skin at the back of its neck (*photo 2*). Then pick up the mouse with both hands and transfer the tail to the hand holding the neck so that the tail is held firmly between your last two fingers (*photo 3*). With the mouse held like this, you can easily put an identity mark on it.




Bend in the rim of the can slightly to keep the top from snapping into the can.
HOLE FOR LOCKING BAR

Make a door from ¼-inch wire screen, wiring it to the snap arm of the trap (*above*). Or use the can top, making a hole for the locking bar to pass through and smaller holes for wiring the can top to the snap arm (*right*).

Remember that the mouse will wiggle and try to get away, so be on guard. Be careful not to hurt the mouse by pulling or pinching too hard. And remember, it takes practice.

If you want to keep an animal for several hours, a large, dry aquarium with a screened top is excellent for observing your catch. Be sure that the animal has plenty of food (such as grain or sunflower seeds) and water. Most kinds of wild mice will tame easily and often make good pets, but it is best to let your catches go free soon after you have caught them. (Let them go in the same place you caught them.) If you should get a bite, treat it as you would any animal bite and get a tetanus shot from your doctor.

Marking Small Mammals

Sometimes it is important to mark an animal you catch so you can recognize it if you recapture it. One good way to mark small mammals is to paint their feet with a dab of model maker's paint. The paint will wear off in a month or two but this is all the time you'll need for most of your investigations. By using different colors and different combinations of colors you can mark a great many animals so that you can identify them quickly.

You might start by painting a different foot yellow on each of four mice. Then you could switch to a different color. You can also use different combinations of feet and finally different combinations of colors. Whatever system you use, be sure to keep notes on how each animal is marked.

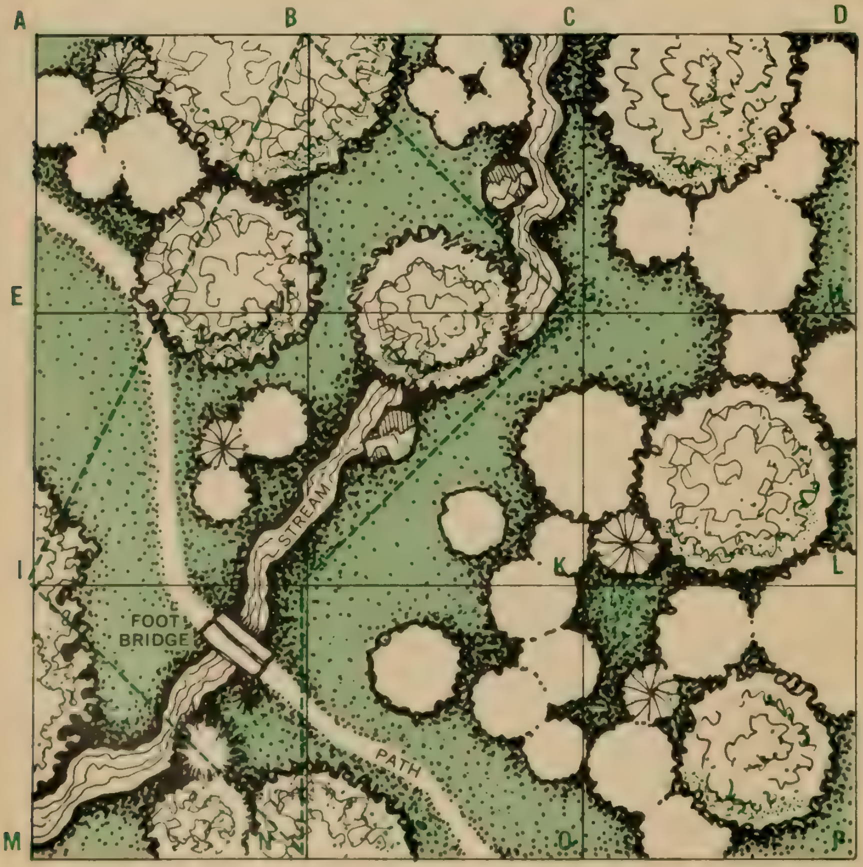
Try to keep the animal from licking the wet paint and from breathing too much of the fumes. Keep the animal in a cardboard box with an open top until the paint dries. Before trying to mark any animals, be sure to read about handling small mammals *(see page 11)*.

As you learn more about trapping small mammals, you may think of some investigations to try. The article "How To Take an Animal Census," *(N&S, Feb. 21, 1966)* may give you some ideas. You might also try to discover the size of the home ranges of different small mammals.

How Big a Home?

To learn about the home ranges of mice and other small mammals, begin by picking an area that is the same throughout—all woods, for example. Then make a simple map of your area and divide it into a grid *(see diagram)*. Take the map with you as you set the traps, putting a trap at the places where the corners of grid's squares meet each other. You might begin by trying squares 50 feet by 50 feet or 100 feet by 100 feet.

A grid system is often used by biologists when they are trapping small mammals. If you put the traps anywhere



Make a map of the area you are going to trap, drawing in features like streams, paths, buildings, and fences. Then draw a grid on the map, marking the corners of the grid's squares with letters. The corners are 100 feet apart on the map shown here. Set a live trap at each corner and keep a record of where you catch certain mice. When you catch one mouse in several different traps, you can get an idea of the shape and size of its home range. For example, suppose a mouse was caught in traps B, I, N, J, and G. By drawing a line (*left*) that connects all of these corners on the grid, you get a picture of the animal's home range.

you wanted to in your area, you might neglect some good places. The grid helps you prevent this kind of a mistake by having the traps spaced evenly over an area.

Set all the traps in the evening. Check them early the next morning. If you find an animal in one of your traps, mark it. Then make careful notes of **1)** what you caught, **2)** how you marked it, **3)** date and time of day, and **4)** where (on the map's grid) you caught the animal. A scientist would also be interested in the animal's measurements, sex, and weight.

Let the animal go in the same place that you caught it, and then rebait and reset your trap. You should check your traps again in the evening. Each day you do this, you will probably find that some animals will turn up in your traps again and again while others will have been caught for the first time. Eventually, you will catch most of the small mammals in the area. If you keep good records, you should be able to find out quite a lot about them.

Suppose you caught one mouse in several different traps. You could mark the positions of the traps on your map *(see diagram)*. By drawing lines that connect the different trap positions, you will get an idea of the home range of one mouse. You can try the same thing with other mice, and with other kinds of mammals.

More Puzzles To Solve

Biologists use live trapping to learn about the lives of small mammals. Once you start trapping these small creatures you will want to make more traps. The more traps you have, the more you can discover about the small mammals in your area. You will probably find that your traps work best with mice. Moles and shrews are harder to catch alive, because they are less common and do not survive well in traps. Shrews, in particular, can live for only a few hours without food. If you catch a mole or shrew, let it go as soon as you can.

Here are some other questions you can try to answer after trapping an area for a couple weeks:

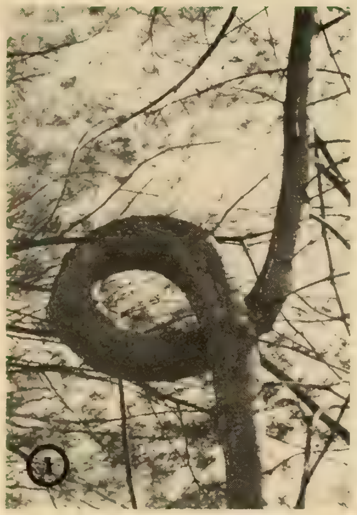
- Which kind of animal did you catch most often?
- Which kind of animal did you catch least often?
- Did you catch more animals during the day or night?
- How many different kinds of animals did you catch?
- Did you have some animals that got caught again and again; others that may get caught only once? If so, can you figure out why? ■

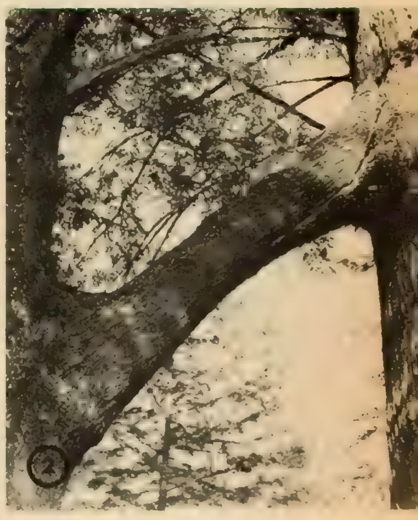
🟩 These books will help you identify mice, moles, and other mammals that you catch: **A Field Guide to the Mammals**, by W. Burt and R. Grossenheider, Houghton Mifflin Co., Boston, 1952, $4.95; **The Mammal Guide**, by Ralph S. Palmer, Doubleday & Company, Inc., New York, 1954, $4.95; **Mammals**, by H. Zim and D. Hoffmeister, Golden Press, New York, 1955, $1 (paper).

WHAT GROWS HERE?

■ Trees sometimes have accidents or are infected with diseases that change their shapes. The photo above shows a bulging growth—called a *tumor*—on the trunk of an elm. A tree tumor forms when an insect, fungus, or injury causes new wood cells to form more rapidly than usual. The tree's trunk bulges as the cells multiply. Tree tumors sometimes grow to be several feet wide.

The two photos below show trees with odd shapes that were not caused by diseases. Can you figure out why the trees grew as they did? Hint: One of the trees had an "accident." (Check your ideas with a forester's explanation at the bottom of the page.) ■





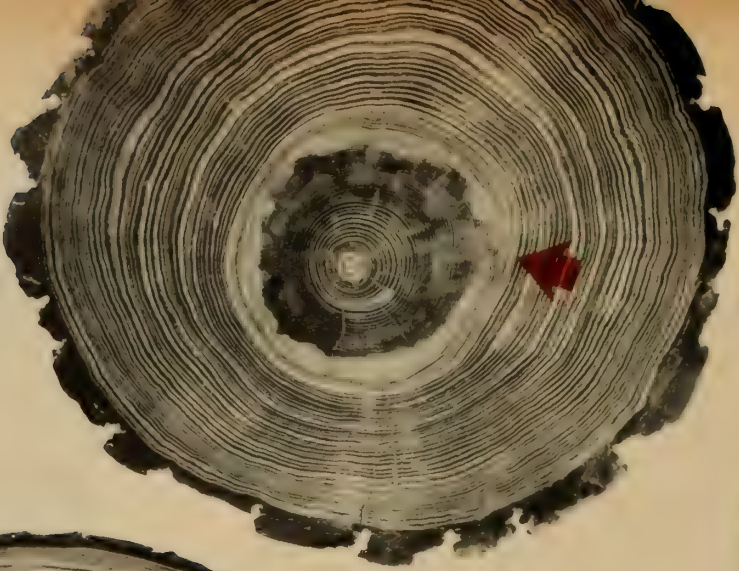
Answers: A tree or heavy limb fell against the pine in photo 1, holding the top of its stem down for some time, perhaps several years. The stem was bent in such a way that it grew in a loop as it straightened up. Eventually the tree or limb that leaned against the pine fell away.

The "bridge" in photo 2 is very rare. Limbs usually grow around objects in front of them. In this case, a limb from the tree on the left grew toward the tree on the right until the limb and tree rubbed together. The rubbing wore off the bark from a part of each and sticky fluid from the wood helped seal the two together. Years later the bridge was cracked in a wind storm.

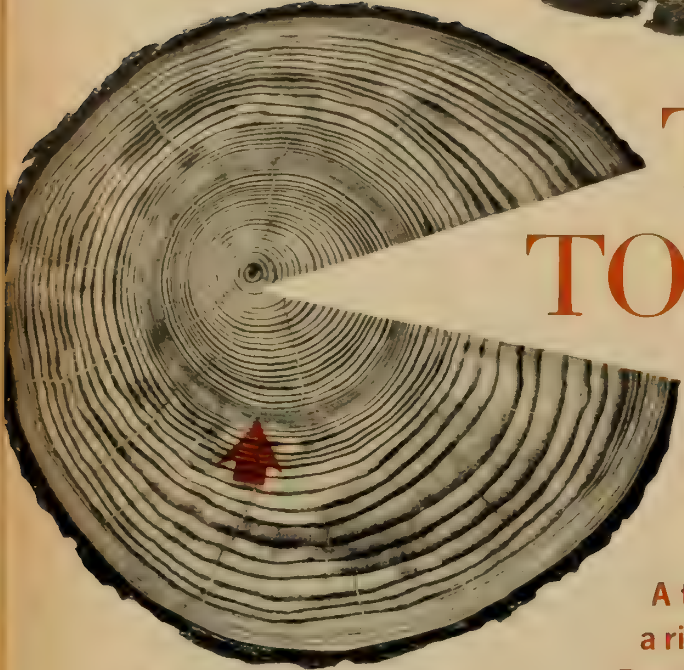
TALES TOLD BY TREES

by Rod Cochran

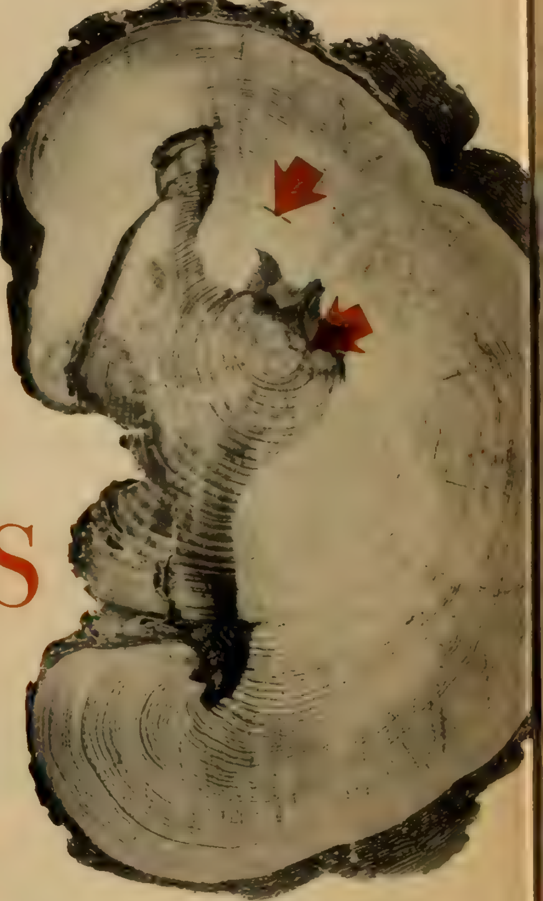
A tree grows by adding a ring of wood each year. By studying these rings you can discover clues to past events in a tree's life.



1 The annual rings of this pine show how its growth has changed through the years. It grew rapidly for its first 17 years, then was crowded by other trees and grew slowly for 64 years. The arrow marks the year when neighboring trees were cut and the pine began to grow rapidly again.



2 This larch grew well for 24 years. Then many of its leaves were eaten by caterpillars and the tree grew slowly for several years (*see arrow*). The closely spaced rings near the outer edge of the tree were caused by another insect attack that began a few years before the tree was cut.



3 This ponderosa pine was burned by nine different forest fires in its 108-year life. The arrows point to some of the fire scars.

■ No matter how large or small a living tree is, it wraps a new layer of wood around itself each year—from the tip of its roots to its topmost twigs. If you cut across a root, tree trunk, or branch, these growth layers can be seen. They are called *annual rings*. One is added each year.

In most of the United States, trees grow their annual rings in two stages. Each ring has a light and a dark band, made of tiny parts called *cells*. The light band grows during the spring. Its cells grow quickly and have thin walls. The new cells produced during the summer grow more slowly and have thicker walls. Because of this, these bands are darker in color.

You may already know that you can tell the age of a tree by counting the annual rings on a stump or log. But annual rings are also records of events in a tree's past—a forest fire, an insect attack, a drought. Next time you come upon a sawed-off stump or log in the woods, see what the annual rings reveal.

As you look at a stump or the end of a log, the annual rings may not be the first thing you notice. If the tree is a large one, most likely there will be a dark section in the center surrounded by lighter wood. The darker part is called *heartwood*, and the wood around it, *sapwood*. The heartwood is the oldest wood in a tree. The cells of the heartwood have become clogged with gums, oils, and brown coloring substances (called *tannins)* which give the wood its dark color. If you look closely, you will see annual rings in both the heartwood and sapwood.

Wide annual rings are formed when a tree grows rapidly. When a tree grows slowly, its annual rings are spaced close together. You may find the stump of a single tree that shows periods of rapid and slow growth *(see photo 1).* Look closely for annual rings with different widths. What do you suppose caused these differences? To figure out the causes, first think about the things that affect a tree's life—sunlight, water, and so on.

Into a Tree's Past

Some species of trees need more sunlight than others. Some grow well in the shade. Others, such as red pine, need a lot of sunlight. They grow slowly when shaded. If bigger trees are cut from around a red pine, giving it more sunlight, the pine will grow faster. Then its annual rings will be spaced farther apart.

Trees also compete for the water and minerals in the soil. Sometimes a few old trees slow the growth of many young trees because the old trees take so much of the water and minerals from the soil through their large root systems.

Insects can also affect tree growth. The pine sawfly, for instance, may eat many of the leaves of evergreen trees. Then the trees cannot make much food. They grow very little, leaving a narrow annual ring for that year *(see photo 2).* The gypsy moth can have the same effect on trees such as oaks and maples. Fire and disease also slow the growth of trees. You may find signs of past forest fires when you look at tree stumps *(see photo 3).*

If rainfall and snowfall drop below normal for a year or more, trees grow slowly. Since the oldest living things on earth are trees, the secrets held within their annual rings are of great interest to scientists. Some kinds of trees have been keeping records of the weather much longer than man has been keeping them, at least in North America. For example, some giant sequoias in California are over 3,000 years old.

Some of the most dramatic annual ring detective work has been done in the southwestern United States. By studying tree rings, scientists discovered that there was a bad drought from about the year 1276 to 1300. This long dry spell apparently caused the Indians to desert their cliff dwellings at Mesa Verde, Colorado.

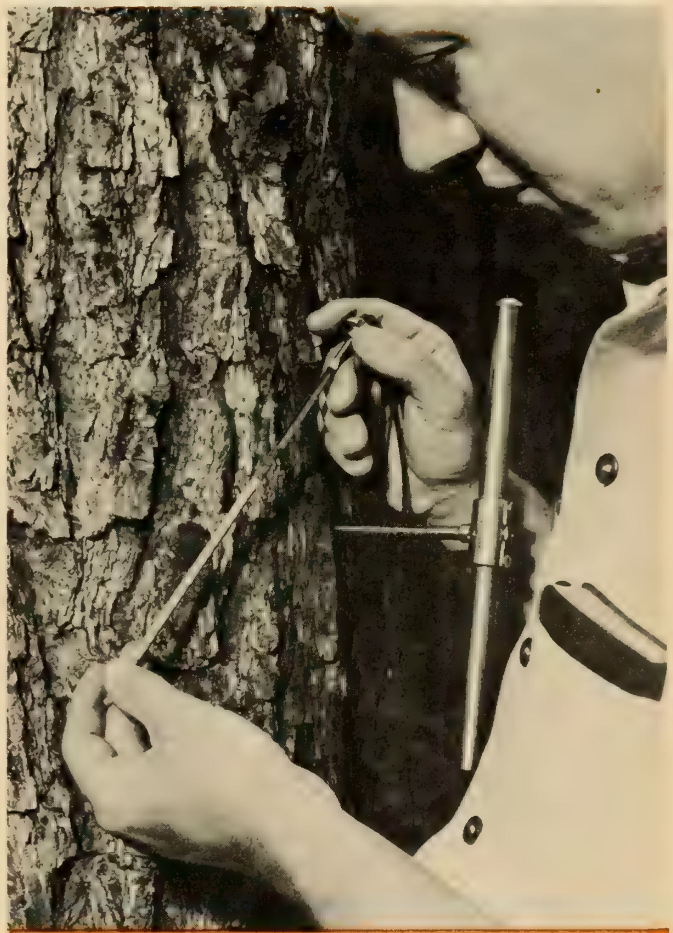
In this case, a tree's history gave a clue to something that happened in human history. The tree stumps you find in the woods may also have some clues to fires, droughts, and other happenings that affected both trees and humans. The pictures on these pages will help you figure out the tales told by tree rings ■

PROJECT

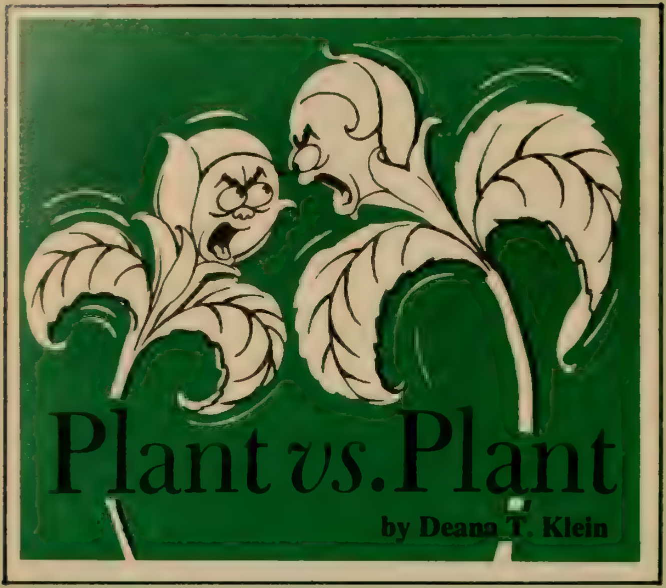
Different kinds *(species)* of trees grow at different rates. If you have stumps or logs of two kinds of trees, you can compare their rates of growth. Measure in inches the distance from the center of each stump to the inside edge of its bark, then count the number of rings. Divide the number of rings into the number of inches and you get the average number of annual rings per inch.

You might find, for example, that a Douglas fir stump had an average of 11 rings to the inch, while a black locust stump had an average of five rings to the inch. Which tree grew at a faster rate?

Would this mean that the black locust tree grew only about one-fifth of an inch thicker each year? (Remember that a tree grows outward in all directions from its center.)



Foresters use a device called an increment borer to see how fast a living tree is growing. As the borer is twisted into a tree, it cuts a rod-like core of wood. This core can then be pulled out and studied. The core shown above has close-spaced annual rings near the bark, a sign of slow growth in recent years.



Plant *vs.* Plant

by Deana T. Klein

■ Plants compete with their neighboring plants for nutrients and water in the soil. They also compete for sunshine. Farmers know this and avoid placing plants so close together that none of them grow as well as they might.

The young trees you see in a forest also compete with each other. You may find dozens of seedlings growing close together. Young trees in a dense forest grow slowly because only a little light filters through the dense cover of the larger trees. Only a few of the young trees survive the competition for nutrients, water, and sunlight.

You can investigate the ways in which plants compete with each other. About all you'll need is some soil, seeds, and a few cardboard milk cartons.

Setting Up Your Investigation

First get six milk cartons and cut one of the long side panels off of each carton *(see diagram)*. Punch several small holes for water drainage in the opposite side. Then fill each carton with damp soil.

In the first carton make small holes in the soil ½ inch deep and 3 inches apart. Put two marigold or mustard seeds in each hole and refill the holes with soil. You will be able to make about three holes in the soil of the first carton. In each of the other cartons, plant the seeds closer and closer together—2½ inches apart, 2 inches apart, and so on until the seeds are planted only ½ inch apart in the sixth carton.

Water each of the carton pots and put them in a warm, light place. As the seedlings start pushing through the soil, be sure that the soil does not become too dry. Otherwise the delicate seedlings will wilt and die. Pull out a few plants so that there is only one seedling growing from each hole.

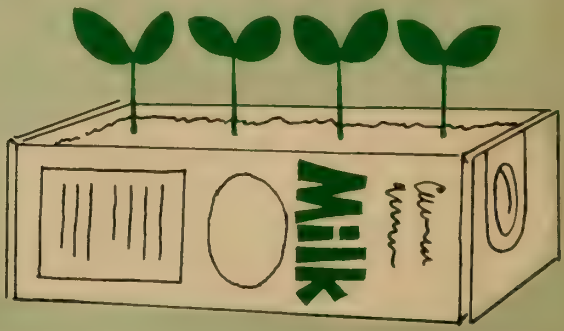
When the plants have several mature leaves (about four to six weeks after planting) cut the stem of each plant at soil level. Then compare the plants from the different cartons. (Be sure that you don't get them mixed up.) Are there differences in height? If there are, in which carton did the plants grow tallest? Measure the length of each plant from each pot; measure from the first leaf to the top of the stem. Then find the average height of all of the plants from each carton. Keep notes on your findings.

As you compare the plants from each of the cartons, notice the size of the leaves. Measure the length and width of the three largest leaves of each plant from a carton. Then compare the average length and width of the leaves from each of the cartons. Which carton had the plants with the biggest leaves? How far apart were the seeds planted in this carton?

Can you decide which carton had the healthiest plants? Remember, the tallest plants are not necessarily the healthiest ones. If you have a balance, find the weight of the plants from each carton. In which carton did the heaviest plants grow? How far apart were their seeds planted?

Do you think you would get the same results if some of the plants were grown in the shade? You can shade some of them with one or more thicknesses of aluminum screening, cheese cloth, or onion-skin typing paper. Or you could water some cartons of plants with a plant fertilizer such as Hyponex and see how the extra nutrients affect the plants. You can also try these investigations using large seeds, such as bean. How far apart should you plant bean seeds in order to get the healthiest plants? ■

Dr. Deana T. Klein is a member of the faculty of the Department of Biological Science of Hunter College, City University of New York.



Make the "pots" for this investigation from cardboard milk cartons with one side cut out. Punch some holes in the opposite side for drainage. The young plants shown in the drawing are spaced 2½ inches apart. Plant seeds at various distances from each other and see how well they grow.

nature and science

VOL. 3 NO. 18 / JULY 25, 1966

SPECIAL ISSUE

THE AMAZING WORLD OF WATER

BIGGER and BETTER BUBBLES

see page 10

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The AMAZING WORLD of WATER

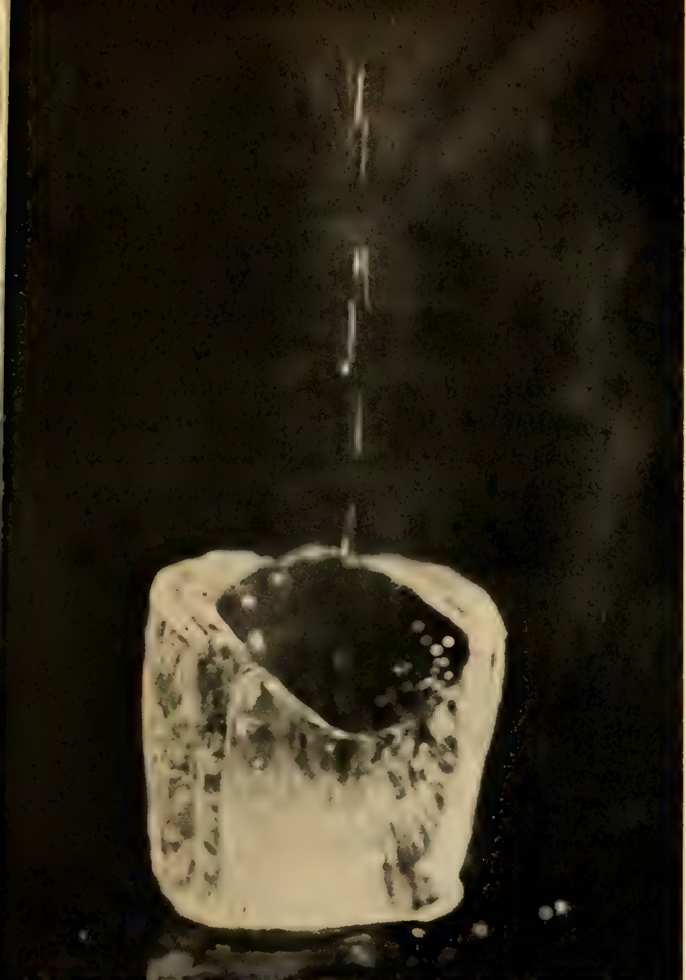
All the articles in this issue of *Nature and Science* are about water. Why write a whole issue about something so common? Even though it is common, water is a very unusual material, as you will find when you read the article beginning on this page. Other articles in the issue suggest dozens of things you can do with water this summer, no matter where you happen to be—even on the desert.

■ The earth, unlike any other planet in the solar system, is nearly covered by water. If you could view the earth from space you would see that we live on huge continental islands rising out of a world-wide ocean. None of the other eight known planets in the solar system, in fact, is known to have bodies of liquid water on its surface.

Water is everywhere around you—in the air you breathe, in the ground, even in the desert sand *(see page 6)*. It is locked up as ice, it flows through rock pores deep underground, and it makes up most of your body. Even though water is all about us on the earth, surprisingly enough it is one of the most unusual substances in nature.

What makes water "unusual"? For one thing, it can creep uphill against gravity. For another, it is *commonly* found as a liquid, as a solid, and as a gas. During a spring thaw in the north, for example, you often find puddles (liquid water) on the ice (solid water), and water vapor (a gas) in the air above the ice. Or within a single cloud on a summer day, there may be water droplets, water vapor, and ice crystals—all existing at about the same temperature.

Water does not necessarily freeze when the temperature is 32°F. If smoke particles or other pollution wastes are



Hot water dripping on ice makes a cloud of tiny water droplets that vanish into the air as colorless water vapor.

mixed with it, water tends to freeze at 32°F. But particularly clean water prepared in the laboratory can be cooled to about –40°F before freezing!

Water is also one of the few substances that is denser as a liquid than as a solid. If you melted a full measuring cup of solid ice you would end up with *less* than a full measuring cup of water!

As you would probably guess, most of the earth's water is in the oceans. They contain about 317 million cubic miles of water—a little more than 97 per cent of all the water on earth. If you can imagine an ice cube with edges a mile long instead of an inch or so, you can get some idea of the space a cubic mile of water would fill. Most of the remaining three per cent of our planet's water is locked up as glacial ice. The rest is contained in the ground, in lakes and rivers, and in the atmosphere as water vapor.

What IS Water?

Whether it is in the form of a liquid, a solid, or a gas, ordinary water is always made up of the same kinds of building blocks—two atoms of hydrogen joined to one atom of oxygen *(see diagram)*. Both hydrogen gas and oxygen gas are highly explosive, but when they combine as H_2O they become a good fire extinguisher.

PROJECT

Cut two pieces of waxed paper about an inch square. With an eye dropper put one drop of water on each square. Place one square in the direct sunlight, and put the other one in the refrigerator. Which drop of water evaporates quicker?

The smallest possible amount of water is a single molecule made of two atoms of hydrogen joined, or *bonded,* to one atom of oxygen. Many such molecules are moving about in the air around you at this moment. It takes billions of H_2O molecules to form one small raindrop.

The way that water molecules cling to each other, and to other substances, is another way that water is "unusual." If you cool air that has water molecules in it, they slow down and cluster together on cool objects, forming liquid drops *(see page 12).*

As a liquid, water molecules slip and slide over each other freely, breaking and reforming their bonds. Only the molecules at the surface of the liquid have enough energy to break their bonds completely and "escape," or *evaporate,* into the air as water vapor. You can lower the number of "escapes" if you cool the liquid. This slows down the motions of the water molecules, so they have less energy to break away from the surface.

If you cool the water molecules enough, they become locked in fixed patterns called *crystals (see diagram),* which we see as ice.

When most liquids are cooled, they shrink, because their molecules move about slower and slower, and take up less space. This means that a cube of nearly any solid

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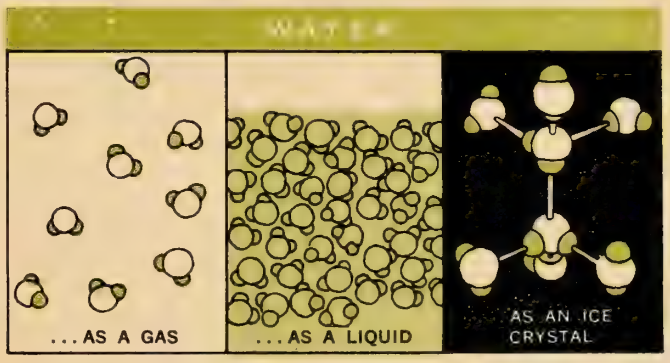


The smallest possible amount of water is a single molecule made of one oxygen atom (open circles) joined to two hydrogen atoms (solid dots). As a gas, water molecules are widely spaced and move about rapidly in the air. As a liquid, the molecules are joined, but are free to slip and slide over each other, breaking and remaking the bonds that hold them together. As a solid (ice), the molecules are locked in fixed patterns called crystals.

PROJECT

Fill a soda pop can to the very top with water then put the can in the freezing compartment of the refrigerator. You can remove the top of the can before you fill it, or leave the top on and pour water in through one of the triangular holes. What does the ice do?

The Amazing World of Water (continued)

substance is heavier than the same size cube of the same substance when it is liquid. But not water. When water molecules crystalize, or turn to ice, they link up in such a way that they take up *more* space than when liquid.

It is this unusual property of water that causes home owners to worry about their water pipes freezing and bursting in winter. But if water did not have this unusual property, life might not be possible. For instance, what if water, like most other liquids, became heavier when it froze? Ice in lakes, rivers, and the oceans would not float. It would sink and these bodies of water would freeze from the bottom up. Eventually, the water cycle *(see diagram)* would be thrown out of balance, affecting living things on the land and in the sea alike.

Water—the "Fluid of Life"

Water molecules cling not only to each other, but also to the molecules of other substances. Their "clinging power" is so great that they can pull apart the molecules that make up salt, sugar, and other substances.

Biologists believe that the first forms of life developed in water, and water is needed in many of the processes that keep animals and plants alive. (It is true that a dried seed can be kept healthy for many, many years without water, but it cannot develop into a plant without water.)

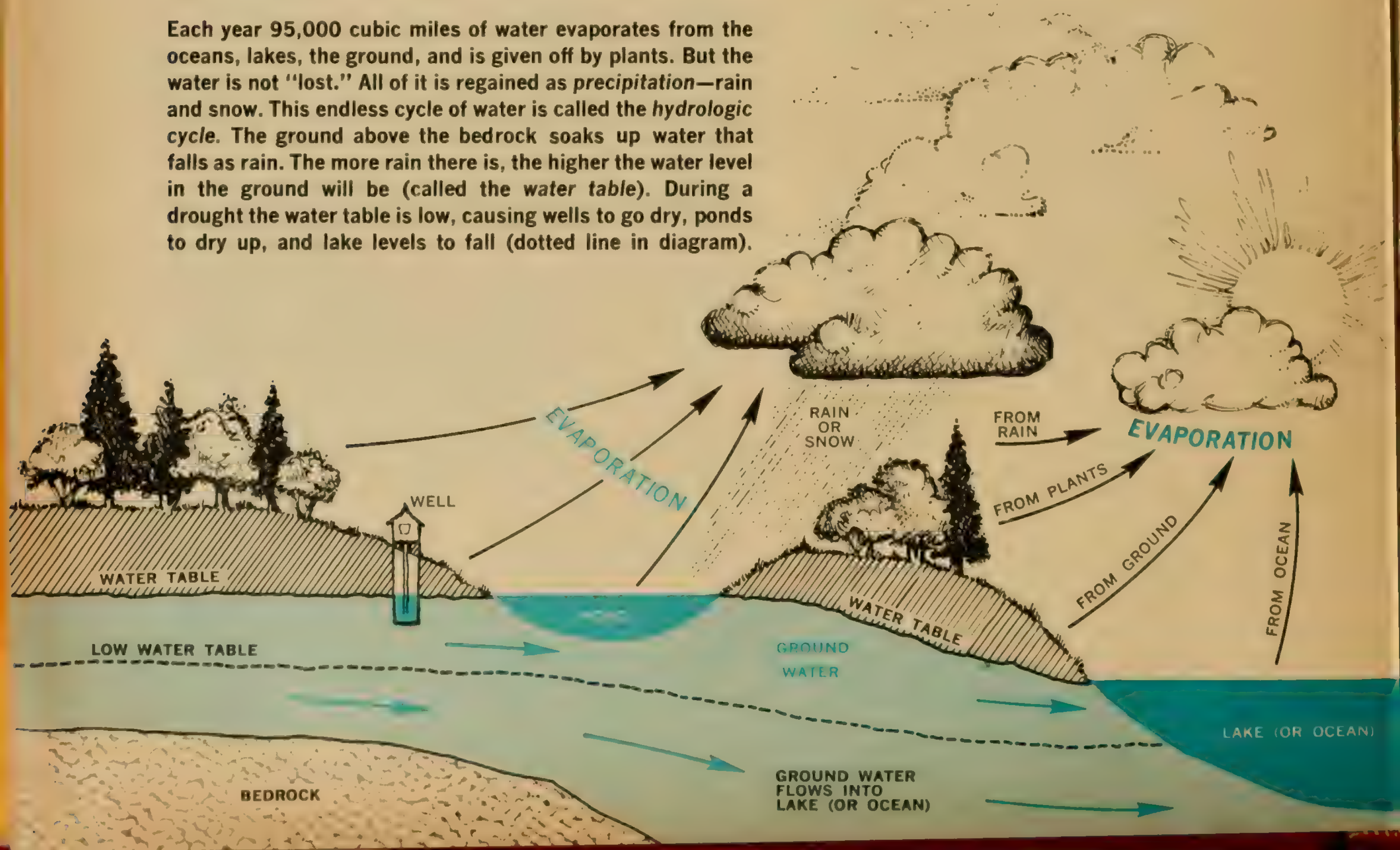
Many of the substances a plant needs to live are dissolved in the water that the plant draws in from the soil. Plants also combine water with carbon dioxide gas to make *glucose*, the sugar-food of plants. In animals, water forms solutions in which food can be broken down and carried to all parts of the body to provide nourishment for the cells that make up the animal. The watery fluids that bathe our cells also carry off their wastes. Water is truly the "fluid of life."

Water—the Master Sculptor

Water is also the master sculptor of the earth's surface *(see page 8)*. After a heavy rain you have probably seen water in the gutters sweeping along dirt and leaves. Rivers, such as the Colorado and Mississippi, pick up and carry along millions of tons of clay, sand, and dissolved salts. These and other materials are carried by the water to the dump heaps of the continental shelves.

In some places—at the mouth of the Mississippi River, for example—the clays and other materials pile up faster than the ocean currents carry them away, so new land is formed. But along other shores—Cape Cod, Massachusetts, for example—the ceaseless pounding of the ocean waves

Each year 95,000 cubic miles of water evaporates from the oceans, lakes, the ground, and is given off by plants. But the water is not "lost." All of it is regained as *precipitation*—rain and snow. This endless cycle of water is called the *hydrologic cycle*. The ground above the bedrock soaks up water that falls as rain. The more rain there is, the higher the water level in the ground will be (called the *water table*). During a drought the water table is low, causing wells to go dry, ponds to dry up, and lake levels to fall (dotted line in diagram).



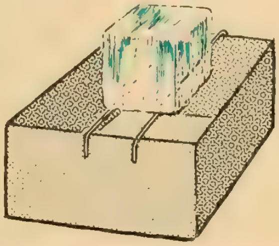
is wearing the land away.

Glaciers, which are rivers of ice, also wear away the land. Often they carry along rocks, boulders, and other materials that gouge and carve the land beneath them. But sometimes the glacier flows around and over rock formations, as a river flows over and around a boulder.

PROJECT

This project will give you a clue about the way a glacier flows over a boulder.

Hook two pieces of fine copper wire over a plastic dish, as shown in the diagram. Then place an ice cube on the wires and carefully place the container and ice cube in the refrigerator (*not* in the freezing compartment). Look at the ice cube every 15 minutes or so to see what is happening to it. How long does it take your "glacier" to flow around its wire "boulder"? Does the wire leave a hole in the ice that has passed around it?



The Travels of Water

Most of the earth's original water supply probably is still on our planet today. In general, water is not "destroyed," it is simply *recycled (see diagram)*. Each year nearly 100,000 cubic miles of water evaporates into the air, but nearly the same amount is wrung out of the atmosphere as rain or snow. A drop of the water that you drank this morning might contain molecules that made up the water drunk by an animal that lived millions of years ago, and carried from a spring by a cave child thousands of years ago. For a while it will become part of your body then will be given up to the earth or air again ■

Did You Know That...

...if the world's total supply of water were poured upon the 50 United States, the land surface would be submerged to a depth of 90 miles?

●

...your body is mostly water? You are about 65 to 70 per cent, by weight, water. (If you weigh 100 pounds, about 65 pounds of you is water.)

●

...in the United States, a drop of water spends an average of only 12 days as water vapor in the atmosphere? It may remain in a glacier for 40 years, in a lake for 100 years, or in the ground for hundreds of thousands of years. Eventually, every drop of water becomes involved again in the water cycle.

●

...industry in the United States needs 32 billion gallons of water each day, mostly for cooling? This is 50 per cent more than we use in our homes.

making water safe to drink

by Bernard Oster

■ The water you find in puddles, ponds, rivers, and lakes usually is not safe to drink, and it may taste pretty awful. This is because it contains such things as soil or sand, chemicals that are dissolved in the water, and tiny animals and plants that can make you sick or even poison you. Here are some simple ways that you can make water from such places safe to drink.

Get some muddy water from a pond, ditch, puddle, or river, or make some yourself with backyard soil. You will also need some sand, a jar, a piece of paper towel (or cloth), and a funnel. Wash the sand by swishing it around in a jar of water then carefully pouring off the water. Next, line the inside of the funnel with part of a wet paper towel so that the towel covers the hole. Pour in the washed sand until it is about two inches deep in the funnel. Now gently pour the muddy water into the sand *(see diagram)* and watch it trickle out of the funnel.

You have just *filtered* the water. If it still looks dirty, wash the sand again, put in a fresh piece of paper towel, and pour the water through a second time.

You cannot be sure that the water you have just cleaned is safe to drink. To kill germs *(bacteria)* that may be in the water, you should boil the water for 15 to 30 minutes. The water should then be safe to drink, unless you took it from near a factory. Such water may contain poisonous chemicals.

If you let a jar of muddy water stand for a while, much of the soil will settle to the bottom by itself. Here's a way that you can make the soil settle faster. To try it, you will need some white crystals of *alum,* which you can buy at a drug store.

Get two baby food jars and fill them with muddy water. You are going to treat only one jar. By *not* treating one

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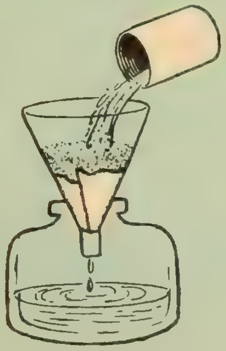


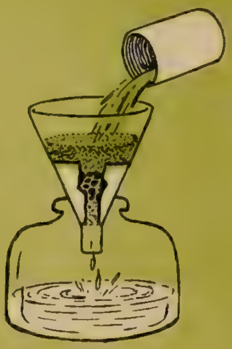
of the jars you will be able to compare what happens.

To one of the jars add about ½ teaspoonful of alum and one to two teaspoonfuls of ammonia. (Remember, ammonia is strong smelling. Don't get it near your nose or eyes, and don't spill any of it on your skin.) Stir both jars well. How fast does the soil in each jar settle to the bottom? Does it take longer to settle in one jar than in the other? The jelly-like material you see in the jar you treated is called *floc*. The soil and most bacteria in the muddy water cling to floc. If you want to drink the water you just purified, be sure to boil it for 15 to 30 minutes to kill the bacteria. You can now improve the taste of the water by pouring it back and forth in two glasses for a minute. This returns to the water oxygen that was driven off by boiling.

At reservoirs which supply water to cities, the water goes through a *flocculation* process in big settling tanks before it is filtered through sand, gravel, and other substances.

Taking Color out of Water

Sometimes water has color, which is caused by decaying leaves, logs, and other living things. When it does, the color is removed at the reservoir. If the water you collected and purified does not have some color to it, you can color some water by adding a drop or two of food coloring or ink. To get rid of the color, here's what to do. You will need some black powder called *activated charcoal* (also called *activated carbon*). An ounce of it will be more than enough. You can get some at a drug store or at your dry cleaning shop.



Set up a funnel and jar as shown in the diagram. Line the funnel with a wet paper towel, as you did before, then pour about an inch of washed sand into the funnel. Next pour in a one-inch-thick layer of the charcoal, then another one-inch-thick layer of sand so that you have a charcoal sandwich. Now pour the colored water onto the top layer of sand and watch the water as it drips out ■

PROBLEM

If you live near the ocean make some muddy water out of salt water and soil, then purify it by filtering it and boiling it. When you taste the purified water does it still taste of salt? If it does, can you think of a way to remove the salt? Does the following article about getting water in the desert give you a clue?

■ You are in the desert. Sand stretches away from you for as far as you can see. The sun is burning down on you and your mouth is dry and parched. You unscrew the top from your canteen and hold it to your lips. Nothing. What do you do now?

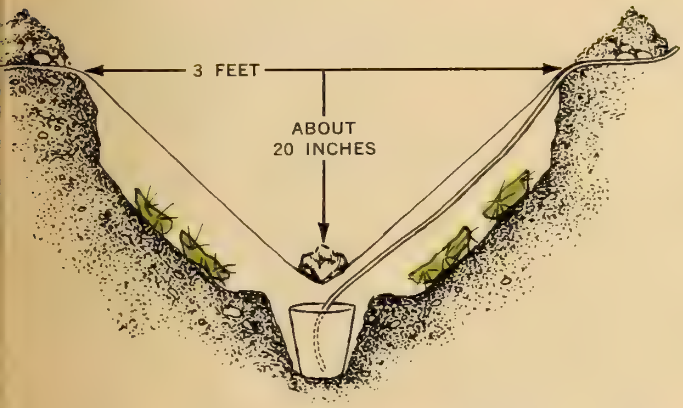
That's simple. You take out of your knapsack a sheet of plastic six feet square and a bucket and in a few hours you have enough pure water to quench your thirst.

Two scientists from the U.S. Water Conservation Laboratory near Tempe, Arizona have designed a simple "survival still" that uses energy from the sun to produce drinking water from desert sand, soil, or bits and pieces of plants.

The scientists are Dr. Ray D. Jackson and Dr. C. H. M. van Bavel. Dr. Jackson got the idea while he was testing solar stills used to purify salty water and make it drinkable. If energy from the sun could be put to work to purify salt water, he thought to himself, surely it could be made to trap water from the ground. When Dr. van Bavel heard about the idea he designed the "hole-in-the-ground" still shown above.

tting drinking water from the desert

This simple solar still could be a life-saver.



This scientist is drawing water into a collecting jar to measure the amount of drinking water produced by his plastic-sheet-and-bucket solar still set up in the desert. The sheet of plastic hangs into a hole about 3 feet across. A rock keeps the tip of the plastic cone above the bucket. Water vapor from the ground, and from chopped-up plants, condenses on the plastic and drips into the bucket.

How To Set Up the Still

First, dig a cone-shaped hole about three feet from rim to rim. In the center of this hole, dig a smaller, straight-walled hole for the bucket. The large and small hole should be just deep enough so that the center of the plastic sheet can hang an inch or so above the bucket *(see diagram).*

The plastic is held in place by loose earth packed around the edge *(see photo).* A fist-sized rock should then be placed at the center of the plastic sheet. This will keep the walls of the plastic straight and will keep the point of the cone over the bucket. It is important that the plastic does not touch the ground except at the top edge where it is anchored.

Where the Water Comes From

Although the top layers of desert sand feel dry, a few inches beneath the surface there is moisture around the sand grains. The moisture can come from rain or from deep ground water, some of which seeps up toward the surface. As soon as you set up the still, moisture in the ground begins to evaporate into the air trapped beneath the plastic. In other words, the liquid ground moisture changes into the gas, *water vapor.*

When the air in the trap has taken up as much water vapor as it can hold, the water vapor touching the plastic begins to change back to liquid water and drips down into the bucket. A plastic that has a slightly rough surface works better than slick plastic. If the surface is too smooth, some of the water drops will fall off before reaching the bucket.

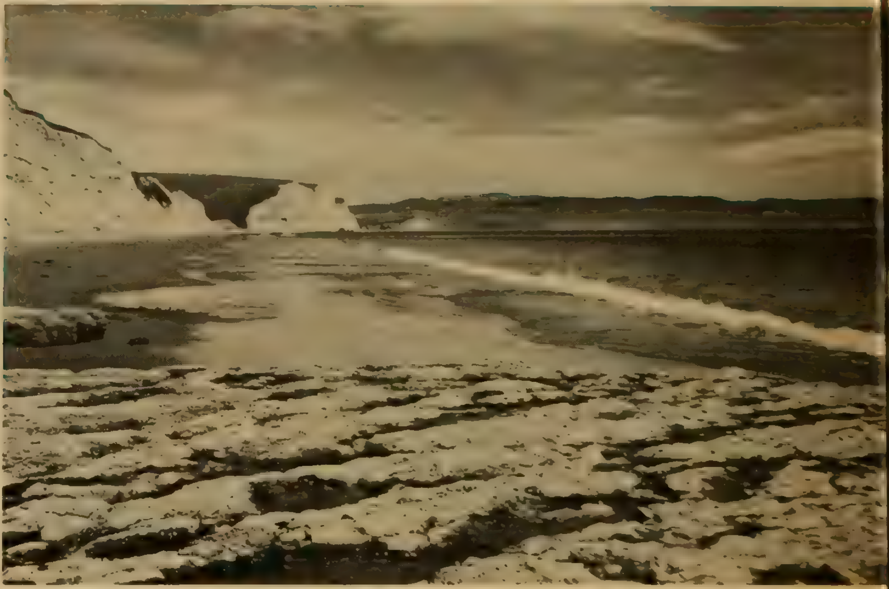
In daytime the moist air trapped beneath the plastic becomes hotter than the plastic itself, so the water vapor condenses on the relatively cooler plastic. At night, the plastic sheeting cools rapidly, but so does the sand. Therefore, not so much water condenses.

This table shows the amount of water a solar still like one described in this article could be expected to produce during one day from soil and from desert sand. The figures are based on experiments carried out by Dr. Jackson and Dr. van Bavel in 1965 near Phoenix, Arizona.

Date	Water from Loam Soil	Water from Desert Sand
April 24	nearly 2 quarts	nearly 1 quart
April 25	more than 1½ quarts	more than ½ quart
April 26	more than 1½ quarts	less than ½ quart

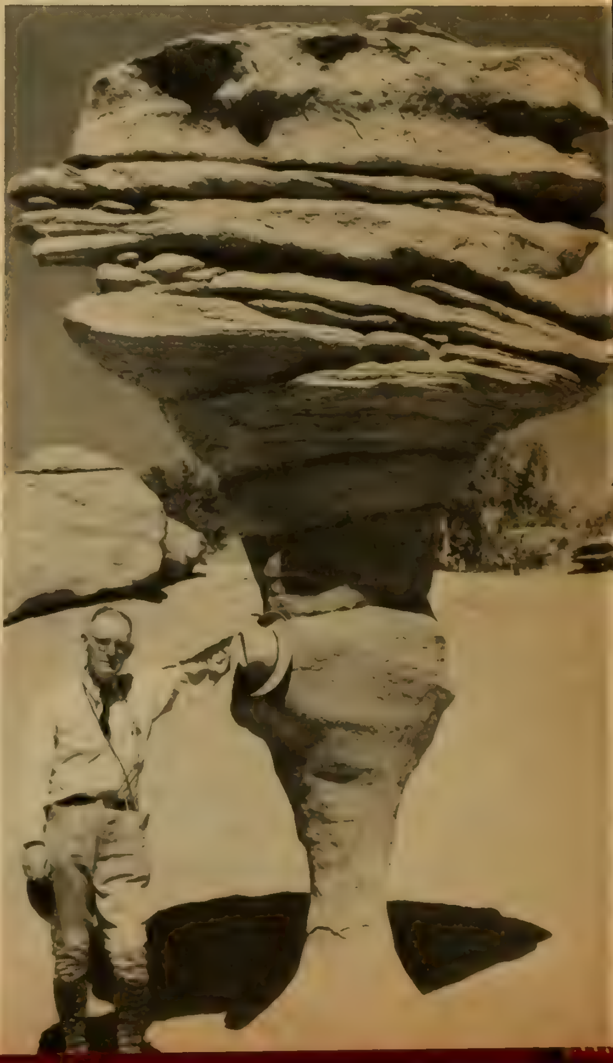
The output of the still can be increased by placing pieces of cactus or other vegetation along the sloping walls of the hole, but not touching the underside of the plastic. The still then draws moisture from the plant tissues as well as from the ground, producing water that should be perfectly safe to drink ■

How water

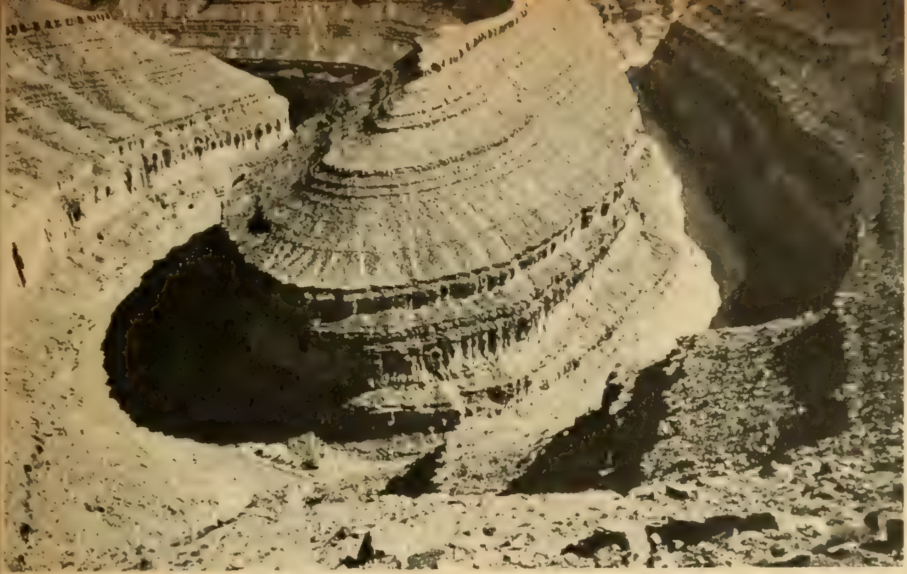


For thousands of years ocean waves have been pounding and wearing away parts of the coast of California. The headlands of Drake's Bay, shown here, are gradually being cut back by the sea. Earthquakes further weaken coastal strips of land and cause them to slump into the sea.

Fire Island, New York, is a famous summer colony that is rapidly being changed by the sea. The photo shows one place where giant waves have carried sand from the dunes as much as 200 feet farther up on the island. In another place, powerful waves washed away a sand dune almost 50 feet wide within 24 hours during an unusually severe storm.



Pedestal Rock, a geologic wonder in Utah, stood delicately poised on its thin stalk for centuries until visitors to the area knocked it down. The rock was shaped by rain water soaking down into the rock from the top. As the softer parts of the rock dissolved more quickly than the harder parts, the rock took on this unusual shape. Wind-blown sand also has helped shape the rock.



The San Juan River in Southeastern Utah loops back and forth in a long series of "goosenecks" like the one shown here. Five million years ago, when the river snaked its way along the same course, forces within the earth caused the land to rise. This made the river flow faster and cut into the soft rock (mostly shale) more rapidly. The cuts are about 2,000 feet deep today.

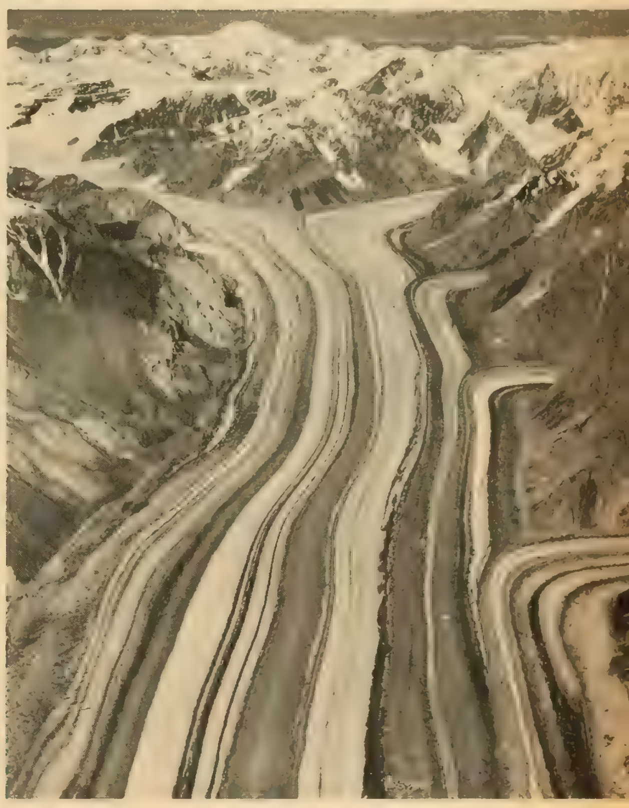
shapes the land

■ Water is the master sculptor of the land. Rain, ice, ocean waves, rivers, and streams are always changing the surface of our planet. In some places—along the California coast, for example—the ceaseless pounding of the sea is eating away the land. In other places, such as the Mississippi River Delta, water carries sand, soil, and clay to the river mouth and dumps it there. In such places the land is gaining over the sea.

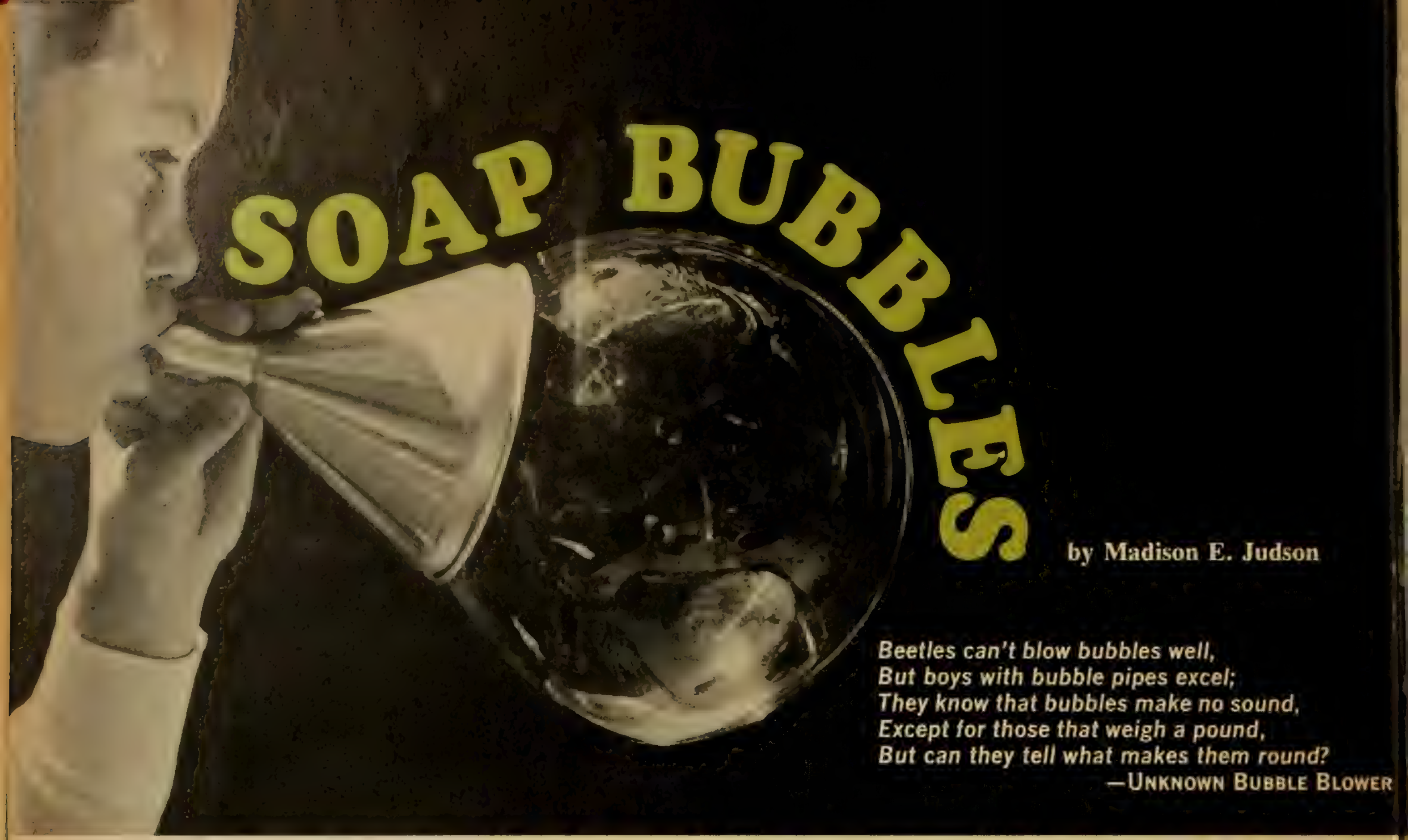
Rivers and streams also sculpture the land. The Colorado River has cut 5,000 feet through the rock over a period of five million years to make what we call the Grand Canyon. Another dramatic example of this kind of cutting action is found at a "gooseneck" in the San Juan River (see photo).

Glaciers on the move also carve the land beneath them, carrying soil, boulders, and other materials many miles along their course. The boulders in many northern states were carried down from Canada by glacial ice, tens of thousands of years ago.

In addition to washing away exposed soil and clay, rain water dissolves soft parts of rock more rapidly than it breaks down the harder parts. Wind-blown sand then joins forces with the rain in wearing away the softer material and sometimes leaves dramatic rock forms such as the great natural arches in Utah, and Pedestal Rock (see photo) ■



This great river of ice is Barnard Glacier, Alaska. As it moves along its valley it picks up and carries thousands of tons of rock, soil, and other materials. The white streaks are ice. The dark streaks, called moraines, are ice mixed with rock and soil. Notice that the wide medial, or middle, moraine is formed by two smaller lateral, or side, moraines that meet where the two glaciers become one.



SOAP BUBBLES

by Madison E. Judson

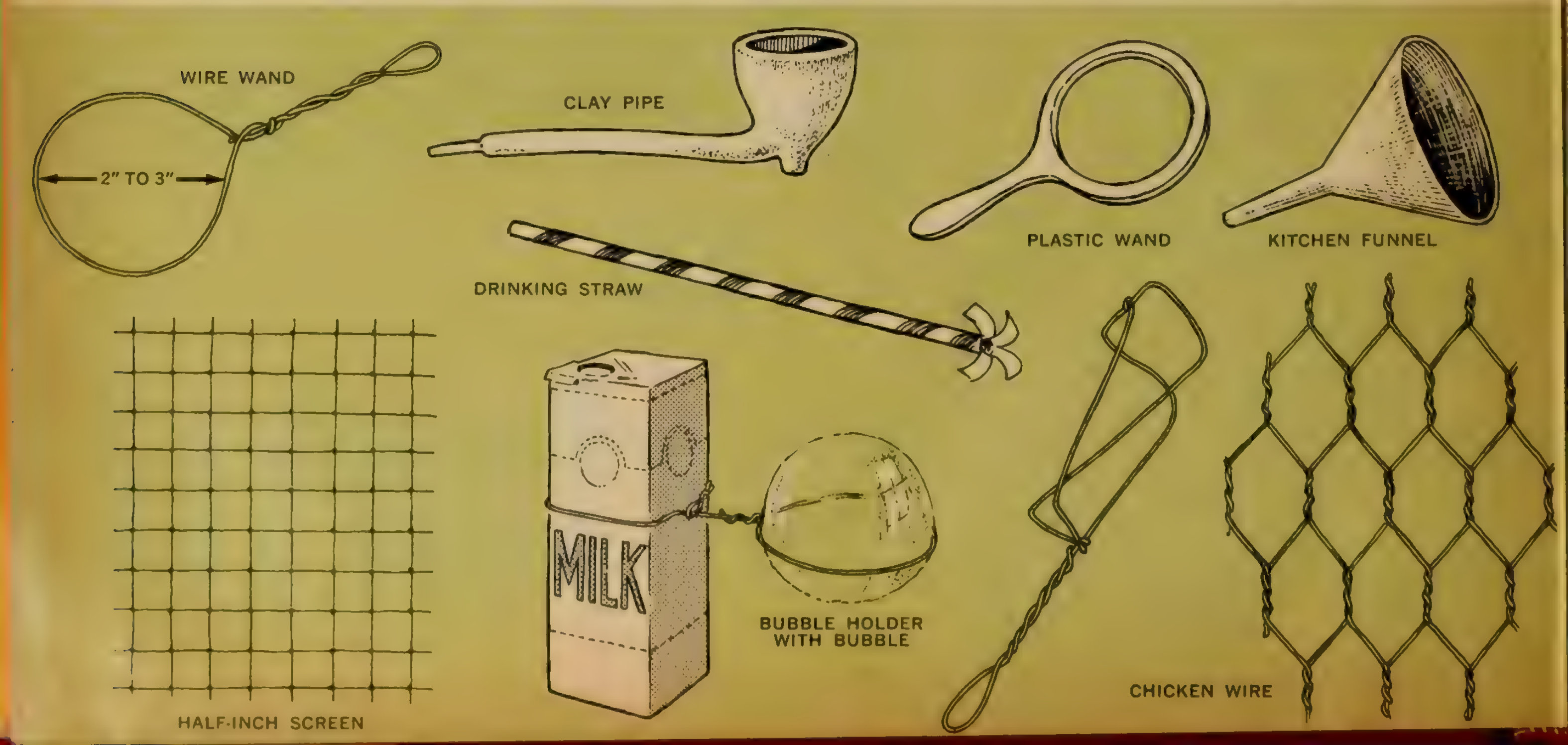
Beetles can't blow bubbles well,
But boys with bubble pipes excel;
They know that bubbles make no sound,
Except for those that weigh a pound,
But can they tell what makes them round?
—UNKNOWN BUBBLE BLOWER

Soapy water makes bigger and better bubbles than plain water because a soap bubble's "skin" is made of a thin layer of water sandwiched between two layers of soap. The soap layers help keep the water layer from evaporating.

■ "What do you know about soap bubbles?" I asked a friend of mine in the fifth grade. "They pop!" she said, and that was that. What she meant was that bubbles usually break just when you want to look at them a little while longer. The amazing thing about bubbles is not that they pop, but that they form at all.

If you want to become a bubble observer, there is no need to go out and buy bubble mixes; you can make your own. All you have to do is mix two caps of Lux liquid with one cup of water. Then if you add one teaspoon of sugar the bubbles you make will last longer than bubbles made with soapy water alone.

You can use water out of the tap, but rain water is better, because it doesn't have the chemicals that sometimes


WIRE WAND
2" TO 3"
CLAY PIPE
PLASTIC WAND
KITCHEN FUNNEL
DRINKING STRAW
HALF-INCH SCREEN
MILK
BUBBLE HOLDER WITH BUBBLE
CHICKEN WIRE

make tap water "hard." When you mix the detergent and the water, make sure that the water is cold. Cold water will keep the suds down.

The drawings on this page show several bubble-blowing tools that you can make or buy. You can even use an ordinary drinking straw; if you do, split and fold the end back, as shown in the drawing. A kitchen funnel works well, too, but you will have to wet the inside of the funnel with the soap liquid before blowing through it. You can buy a plastic wand, or you can easily make one out of wire. Making bubbles with wire screening—half-inch screen is best—can also be fun. Try using large-hole screen, such as chicken wire, also.

Whatever kind of bubble wand you use, dip the wand into the soap liquid, lift it out, then gently wave it through the air to form bubbles. To free a bubble from the wand, twist the wand gently when the bubble is just about formed. If you blow through the wand, blow gently; otherwise you will break the soap film. If you want to make large bubbles, dip the big end of the funnel into the bubble solution (after wetting the inside of the funnel), then blow gently through the small end. If you run out of breath before you finish making the bubble, stick your tongue over the opening while you take another breath. This will keep the bubble from collapsing.

When the large end of the funnel is dipped in the soap liquid, a soap film will form across the mouth. Watch the soap film. It will travel up the funnel. Can you figure out why it does?

Make a bubble holder *(see diagram)*, so that you can study a bubble closely. After you make a large bubble with the funnel, see if you can put the bubble on the wet wire loop of the bubble holder. Then, using another wet wire loop, see if you can remove the bubble again.

3 PROJECTS

For Bubble Experts Only

- Did you know that you can put your finger inside a bubble? First wet your finger with the soap liquid. Your finger will then pass easily through the wall of the bubble without breaking it.
- Place a large bubble on a wet surface. Then wet a drinking straw in the bubble liquid and push the straw into the bubble. Now see if you can blow another bubble inside the first bubble.
- Try to freeze different soap films. Put a soap film frame in the freezer of your refrigerator. What happens? Can you find a way to freeze a soap bubble? Could you freeze one outside in the winter when the temperature is below freezing?

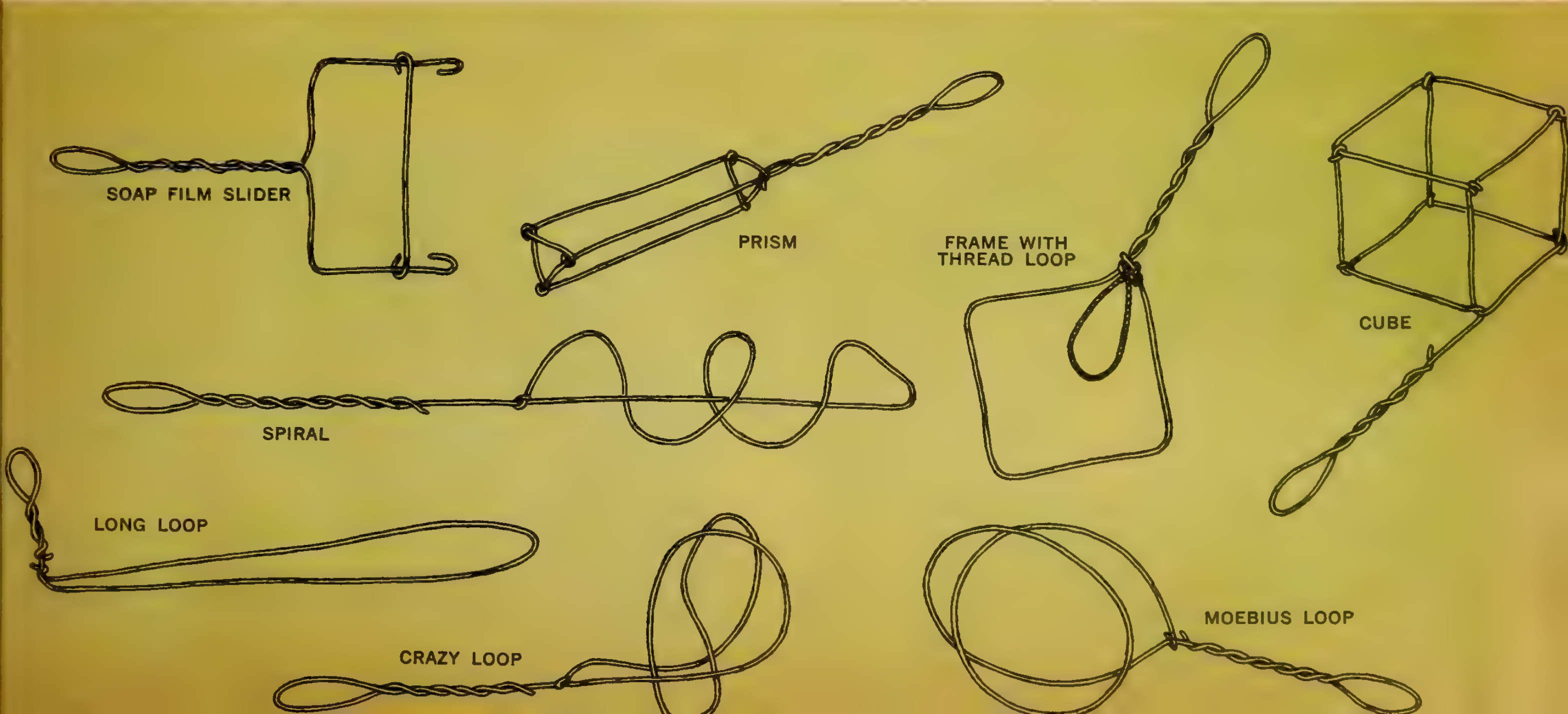
Experimenting with Soap Films

A bubble is only one shape that a soap film may take. Many other shapes are easy to make by bending wire into frames of different shapes and stretching a soap film over them. Number 20 copper wire is easy to bend, but any kind of wire that stays in the shape you bend it will do.

Make a long-loop bubble wand *(see diagram)*. The loop should be about two or three inches across. After you have dipped the loop in the soap liquid, lift it out and hold the wand edge-up. Watch the soap film as it gradually develops bands of color.

By making a soap film slider like the one shown in the diagram, you can have a tug-of-war with a soap film. When you remove the slider from the liquid, watch to see what happens. Pull the slider out and watch the soap film stretch. Release the slider and watch the film contract.

(Continued on the next page)



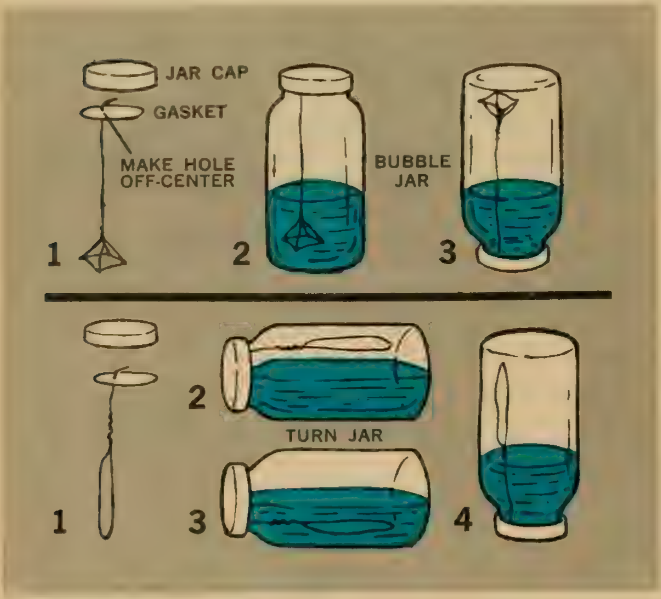
Soap Bubbles (continued)

Make a thread loop inside a square wire frame. The thread should be light weight and made of silk or rayon. Dip the frame and loop in the bubble liquid, take it out, then touch a paper towel or tissue to the inside loop. Watch what the rest of the soap film does.

Invent some wire-frame shapes of your own. Maybe the cube and prism shapes shown in the diagram will give you some ideas. The soap films form in surprising ways when you use frames like these. Try to make a soap film form on all six sides of the cube. Maybe it can't be done.

Some unusual things happen when you use a spiral frame. Study the one in the diagram, see how the loops wind around, then make one like it. Make a "Moebius" loop and find out what happens to it after you dip it into the liquid.

You can watch a soap film for quite a long time if you use a bubble jar *(see diagram)*. Your wire frames can be held firmly by the gasket, or cardboard, inside the cap. You can cut a good gasket from an old inner tube. As the diagram shows, make the hole in the gasket near one edge of the disc, *not at the center*. By making the hole near the edge you will not need as much bubble liquid as you would if you made the hole in the center of the disc. When the bottle cap is tightened in place, turn the bottle on its side and roll it so the wire loop dips into and then out of the liquid. You can then stand the bottle upright to study the soap film. Make a four-sided frame also, and see what happens to the soap films that form on it.



The many projects in this article are only a few of the things you can do with bubbles and soap films. Once you start experimenting you will discover dozens of other things to do and to look for ■

WATER'S TOUGH "SKIN"

If your feet were big enough, you could walk across a pond as a "water strider" does. Here is a way to investigate the tough "skin" of water.

■ If you sit on the edge of a small pond on a summer day, very likely you will see a water strider *(see photo)* skipping along the surface. These insects dart about rapidly. Even though they are heavier than water, they skate over it and never get wet. If you watch one skimming over a pond surface, or if you are able to catch one of them and watch it in an aquarium, you will see that its legs make dimples in the water surface, and never break through.

Like the water strider, many things that are heavier than water will float—a paper clip or a needle, for example. Use a partly unbent paper clip as a platform to lower another paper clip or needle to the surface of the water *(see photo)*. It is better if the paper clip or needle is dry and clean.

Did you know that you can float a plastic berry basket, or a piece of wire screen? Try it. Once they are floating you can get a good look at how elastic the water's surface is by using a magnifying glass. Although water seems to have a skin, water's surface "skin" is not a true skin, such as that of an animal. (Try to peel the "skin" off water. What happens?) See if you can find some liquids that seem not to have a "skin." What about oil, or vinegar?

The surface "skin" of water is tough and quite elastic. It

You can float a paper clip on water by lowering it to the surface on a platform made of a partly unbent clip. For best results, the clip to be floated should be dry and clean.

can stretch a great deal before it breaks. Using a clean dry fork, gently press against the surface "skin" of water. Watch closely. Slowly press a spoon flat against the surface. Watch the edges of the spoon as you press it deeper against the surface.

Measuring the Toughness of Water's "Skin"

Is the surface "skin" of water made tougher if soap is added? Or is it weaker? Find out by floating a paper clip on the surface of water and then gently add, drop by drop, soapy water. Try the experiment again, but this time use oil instead of water.

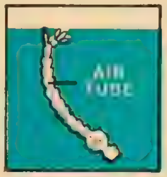
Here's how you can measure the toughness of the surface "skin" by using a homemade balance *(see diagram)*. Make the balance level, then place a container of liquid so that the balance pan touches the liquid's surface. Next, add paper clips or thumb tacks to the free pan until the other pan breaks away from the water surface. The more paper clips or thumb tacks that you can put in the free pan without pulling the other pan away from the water, the greater the toughness of the surface "skin." Record your findings on a chart such as this one. Be sure that the bottom of the floating pan is flat, clean, and dry when you use it. (You could use different jar caps as pans, but make sure each time that the balance is level before touching the one pan to the surface of the liquid.)

Try some other experiments of your own with surface "skin." We call the surface "skin" of water *surface tension*. Whatever you call it, liquids behave in interesting ways.

—MADISON E. JUDSON

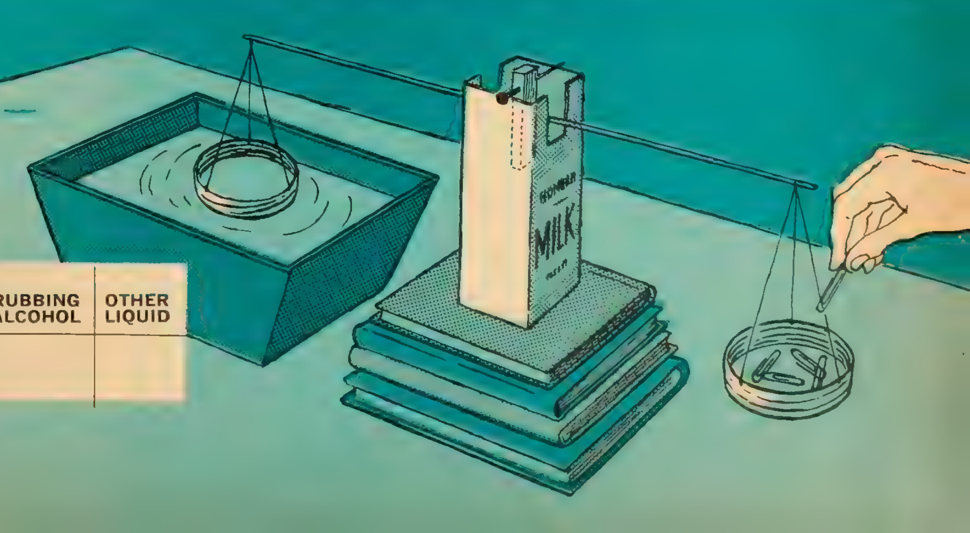
PROJECT

The surface "skin" of water makes it possible to control mosquito larvae, which breathe air but live under water. In the summer, set a bucket of water outdoors. In a few days you may find mosquito larvae in the bucket. From time to time the larvae rise to the surface and puncture the water's "skin" to breathe.



Oil has a tougher surface "skin," which mosquito larvae cannot pierce. Oil spread over water has to be only one millionth of an inch thick to suffocate the mosquito larvae.

Use a balance like this to test the "toughness" of the surface "skin" of different liquids, and record your findings in a chart like the one below.

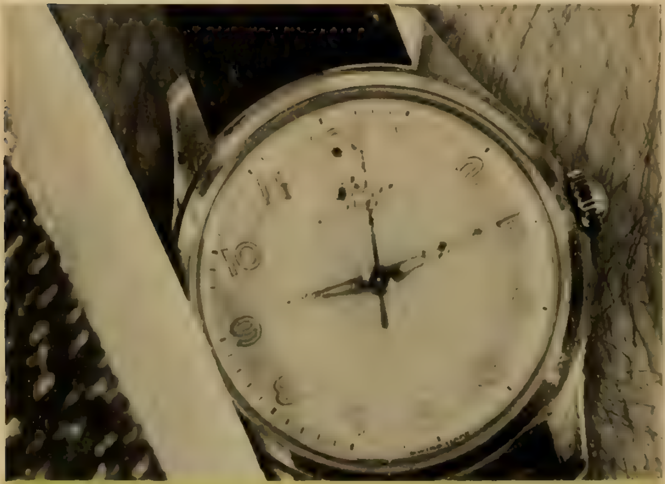


NUMBER OF THUMBTACKS OR PAPER CLIPS	WATER	SOAPY WATER	COOKING OIL	VINEGAR	RUBBING ALCOHOL	OTHER LIQUID

The water drops on the leaf at the right are dew drops. The water drops on the leaves at the far right came out of the leaves themselves. This kind of water is called *water of guttation*, and it always forms along the edges of the leaves, never on top or bottom. Water of guttation is common only on calm, clear nights when the temperature is low and there is no wind.

WHAT DOES DEW

■ Have you ever gone on a dew hunt? Try it sometime this summer and find out if there is usually more dew in the morning, afternoon, or evening. See if the weather makes any difference in how much dew you find. Do you find more dew when the air is windy or when it is calm? When the sky is clear or cloudy? When the air is hot and humid or cool and crisp?



Water has condensed on the inside of the watch glass. Can you explain why the moisture took this pattern?

Does dew seem to form on some things but not on others? Look for dew on plants, trees, rocks, bare ground, pavement, cars, houses, and other buildings. Where is there a lot of dew, and where is there none? Can you explain why?

Put different materials outside and see which collect dew. Try pieces of wood, metal, paper, glass, and rocks. Does more dew form on top of something, on the sides, or underneath? What happens if some of the materials are put in a tree or under a car?

Where does dew water come from? You probably know that dew is not just rain, because dew is often found when the weather is clear. Does dew ooze out of plant leaves? If this happened, it would not explain dew that appears on automobiles or sticks.

Does Dew Mean Good Weather?

Here is an old weather saying about dew. Is it usually true?

When the dew is on the grass,
Rain will never come to pass.
When grass is dry at morning light,
Look for rain before the night.

DO?

by David Webster

Dew actually comes from moisture in the air. The moisture, called *water vapor,* is a gas. When moist air comes in contact with something cool, the invisible water vapor *condenses,* or changes back into liquid water again. The cooler something is, the more dew there will be. Knowing this, can you now explain why dew forms when it does, and why it occurs on some things but not on others? ■

Why Do Animals Sweat?

Did you know that your skin sweats all the time? You can show that it does by holding a plastic bag over your hand for five or 10 minutes. How does your hand feel? Where does the water come from that collects inside the bag?

As your sweat evaporates, it cools your skin. Wet one hand with warm water, and then swing both hands back and forth. Which hand feels cooler?

The reason that the wind feels so cold is that it makes the moisture on your skin evaporate fast. When you are traveling, hold a thermometer out the car window. Is the air much colder when the car is moving? Does your hand feel cooler?

Do other animals sweat, too? Perhaps you have seen a horse perspire after a long run. Dogs sweat mostly through the tongue and the pads of their feet. Do you think birds, snakes, frogs, and fish sweat?

things to DO with water

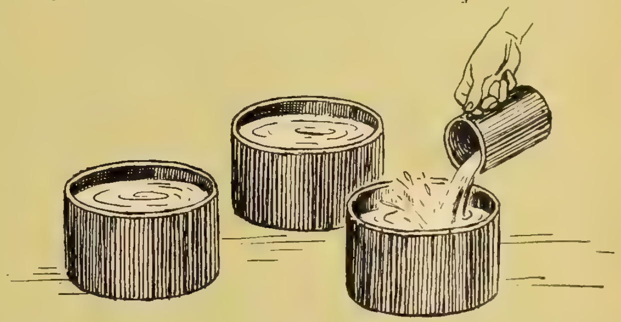
By Donald Ford and Christopher Hale

How Deep Does the Rain Go?

During a rainstorm much of the rain goes into the soil. Suppose one inch of rain fell during the storm. Did it go one inch down into the ground? Two inches? Twelve inches? Does it go down different distances in different kinds of ground?

Try digging in different places after the next rain and see if you can tell how far the rain soaked in. Will it soak deeper in garden soil or in sand? Does it soak in as deep under trees as it does out in the open?

Get some samples of different kinds of soil and dry them out in the sun. Then fill same-sized jars each with a different kind of soil. Tap the bases of the jars gently several times when you are filling them. This will help the soil to settle in the jars. By using a measuring cup, find out which jar of soil you can pour the most water into. Which kind of soil does the water soak into fastest?



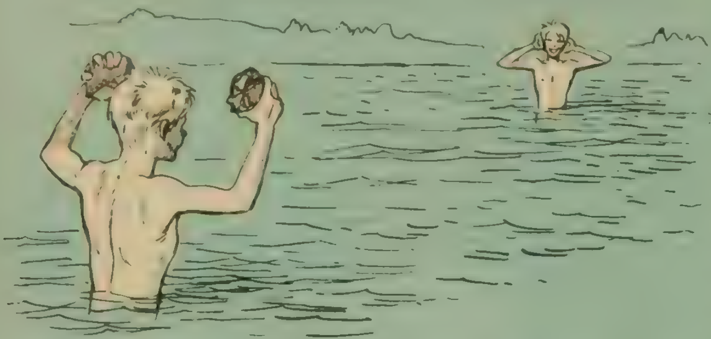
Listening to Sounds Underwater

Do sounds sound the same underwater as they do in the air? Find out by hitting things together in the bath tub, or even better, in a swimming pool or lake. Get two things that make a good noise, like two rocks or tin cups. Hit them together in the air, then hit them together underwater. Do they sound the same? Now put your head underwater and hit the rocks together underwater. Is the sound different? What kind of noise do you hear when your head is underwater and you hit the rocks together in the air above?

(Continued on the next page)

The next time you're swimming at a lake, listen for the sound of an outboard motor boat. Does it sound different when you put your head underwater? Does the boat seem to be nearer or farther away?

Someday when you are at the lake or seashore, ask a friend to hit two rocks together as hard as he can at different distances from you. You could mark off the distances in the sand. Can you hear the noise better if your friend hits the rocks together in the air when your head is above the water, or when he hits them together underwater when your head is underwater? At about what distance can you hear the noise one way but not the other?



Making Your Own Rainbow

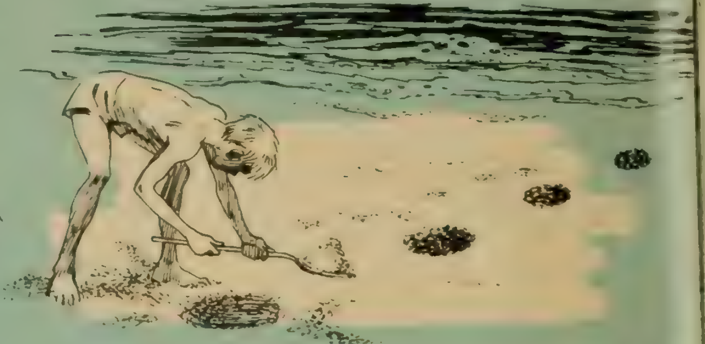
All you need to make a rainbow at home is a sunny day and a hose with an adjustable nozzle. Stand out in the bright sunlight and adjust the hose so that the water comes out in a very fine spray. Aim the spray out in front of you and turn slowly around.

How must the sunlight hit the spray so that you can see a rainbow in it? What colors do you see in the rainbow? Are they the same as the colors you see in a rainbow in the sky? Could you make a rainbow this way on a cloudy day? Could you make a rainbow this way at night by using an outside light bulb instead of the sun?

Does the Water Stop at the Beach Line?

Does the water in a lake or ocean really stop at the edge, where the water meets the sand?

You can find out by digging miniature wells. How far back from the water's edge can you dig a well and still strike water? Do you have to dig your wells deeper and deeper as you move up the beach? Finally, when you don't strike water in a well, try filling the well with water. Will your well hold water?

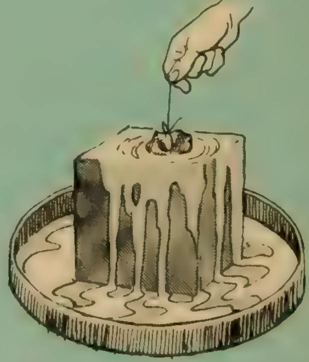


Here's a puzzler. People living very near the ocean often dig wells to get fresh water for drinking. Where does this fresh water come from?

Using Water To Measure Volume

Suppose you have two rocks that look about the same size. How could you use water to find out if they are really the same size?

Get a jar or clear plastic container and fill it right up to the top with water. Tie a string tightly around one rock, then gently lower it into the jar. (The rock must be completely covered with water.) The amount of water that spills out takes up exactly the same space, or has the same *volume*, as the rock. Take out the rock and measure how much water you need to fill the jar again. Do the same thing with the other rock. Were they really the same size or was one bigger than the other?



Now try out this puzzle on a friend. Can he guess which rock is bigger? Can he figure out how to find out?

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